North Saskatchewan River Water Quality Model: Alberta Environment Technical Report

Version 1.1

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Prepared by:

Darcy McDonald, M.Sc., P.Geo.
Deepak Muricken, M.A.Sc., EIT

Summary of Model Revisions

Date	Version.#	Revision	Description

Any comments, questions, or suggestions regarding the content of this document may be directed to:

Water Policy Branch
Alberta Environment
7th Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-2654
Fax: (780) 422-6712

Additional copies of this document may be obtained by contacting:

Information Centre
Alberta Environment
Main Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-2700
Fax: (780) 422-4086
Email: env.infocent@gov.ab.ca

EXECUTIVE SUMMARY

The application of a dynamic water quality model, representing the North Saskatchewan River (NSR) reaches potentially impacted by activities in the Capital Region and Industrial Heartland (IH), was identified by the IH Steering Committee as a key component in providing decision support for implementation of the Water Management Framework. As such, Alberta Environment has developed a hydrodynamic and water quality model, based on the Environmental Fluid Dynamics Code (EFDC) platform, for the North Saskatchewan River system. The use of this model application is in evaluating contaminant loadings and their effect on river water quality under various management and engineering options in the IH area. As well, it is the basis for a larger integrated model of the NSR Basin to support broader-scale watershed and regional planning.

The objectives of the modelling effort described in this report are to:
• Gather data to construct a computer simulation model of the North Saskatchewan River from Devon to downstream of the Alberta-Saskatchewan border, representing a river distance of about 400 kilometers.
• Ensure that the model accurately represents the system hydrodynamics and water quality (flow, temperature, dissolved oxygen and nutrient dynamics).

This report documents the configuration, calibration and validation of the river water quality model for the mainstem of the NSR from Devon to the Alberta-Saskatchewan Border. The model represents hydrodynamics, water temperature, dissolved oxygen, organic carbon, nutrients, algal interactions, and other parameters influenced by tributaries, municipal wastewater treatment plants (WWTPs), industrial facilities, combined sewer overflows (CSOs), and storm water. The model calibration period was from January 2000 through March 2008.

Work continues on the NSR water quality model to improve its representation of other parameters, and its integration with models of the upper NSR reaches and broader NSR basin (under collaborative development by AENV and the NSWA). Updates on model revisions and integration will be released as available.

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LIST OF ABBREVIATIONS

AENV   Alberta Environment
EFDC   Environmental Fluid Dynamics Code
CORMIX   USEPA-supported mixing zone model
CSO   combined sewer overflow
DO   dissolved oxygen
DOC   dissolved organic carbon
DON   dissolved organic nitrogen
DOP   dissolved organic phosphorus
EMS   Environmental Management System
GIS   geographical information system
HEC-RAS   Hydrologic Engineering Centers River Analysis System
HSPF   Hydrological Simulation Program - Fortran
IH   Industrial Heartland
IHWMF   Industrial Heartland Water Management Framework
LPOC   labile particulate organic carbon
LPON   labile particulate organic nitrogen
LPOP   labile particulate organic phosphorus
LSPC   Loading Simulation Program in C++
NH3   ammonia
NO2/NO3   nitrite/nitrate
NSR   North Saskatchewan River
NSWA   North Saskatchewan Watershed Alliance
PO4   orthophosphate
PN   particulate nitrogen
RPOC   refractory particulate organic carbon
RPON   refractory particulate organic nitrogen
RPOP   refractory particulate organic phosphorus
SOD   sediment oxygen demand
SWAT   Soil and Water Assessment Tool
TDP   total dissolved phosphorus
TKN   total Kjeldahl nitrogen
TMDL   Total Maximum Daily Load
TN   total nitrogen
TP   total phosphorus
TOC   total organic carbon
USEPA   United States Environmental Protection Agency
WASP   Water Quality Analysis Simulation Program
WDS   Water Data System
WMF   Water Management Framework
WTP   water treatment plant
WWTP   municipal wastewater treatment plant

1.0 INTRODUCTION

Planning for and managing the impacts of cumulative effects demands a thorough and scientific approach, particularly against the backdrop of unprecedented industrial development within an evolving regulatory environment. Such an approach is required to address contaminant loading issues in the North Saskatchewan River (NSR) Basin.

The Devon to Pakan reach of the NSR supports a population of about 1 million, as well as a large segment of Alberta's petrochemical processing industry. This area is termed the *Industrial Heartland (IH)*, and is the focus of the Water Management Framework for the Industrial Heartland and Capital Region, developed by Alberta Environment in consultation with its partners (AENV, 2008; Figure 1-1).

Alberta Environment's approach to managing water quality includes consideration of the loads of substances entering a water body and their influence on instream water quality. Quantification of critical loads requires an approach similar to the Total Maximum Daily Load (TMDL) methodology utilized by the USEPA (USEPA, 2009). This estimates the maximum loads for contaminants allowed to enter a water body such that desired outcomes for instream water quality are met. Contaminant loads may be allocated to point- and non-point sources, and should account for uncertainty in how well loading predictions relate to actual instream water quality concentrations.

The application of a dynamic water quality model, representing the NSR reaches potentially impacted by activities in the Industrial Heartland, was identified by the IH Steering Committee as a key component in providing decision support for implementation of the Framework. The objective of this model application is to evaluate contaminant loadings and their effect on river water quality under various management and engineering options. The model provides a critical tool for evaluation of effluent wasteload effects in the IH area, and is the basis for a larger integrated model of the NSR Basin to support the load evaluation process as well as broader-scale watershed and regional planning.

This report documents the configuration, calibration and validation of an in-stream water quality model for the mainstem of the NSR from Devon to 38 kilometers downstream of the Alberta-Saskatchewan Border (Figure 1-2). Hydrodynamics, water temperature, dissolved oxygen, organic carbon, nutrients, algal interactions, and other parameters were modelled under the influence of tributaries, municipal wastewater treatment plants (WWTPs), industrial facilities, combined sewer overflows (CSOs), and storm water.

Preliminary development of the model was completed by TetraTech Inc. (Fairfax, VA) for Alberta Environment in May 2009. Since then, ongoing refinements have been implemented by the Water Policy Branch of Alberta Environment. The updated model is discussed in this report along with current results.

As refinement of the model is an ongoing effort, this document is designed to allow information on model revisions to be included as additional updates are completed. A

"Summary of Revisions" tracking table is provided at the beginning of the document to make the user aware of any changes to the document. Updates will be released as available.

Figure 1-1. Industrial Heartland and Capital Region water management area.

Figure 1-2. Industrial Heartland – general map of land holdings.
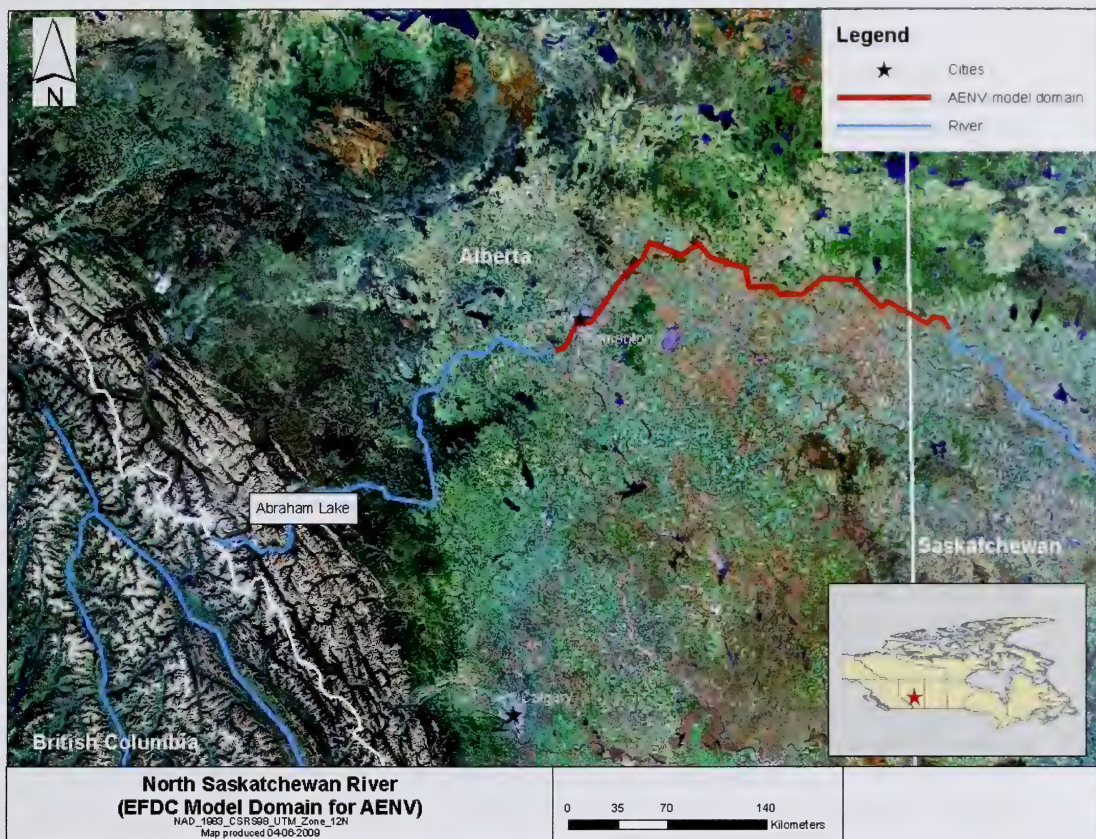
Figure 1-3. Extent of the modelled area of the NSR.

2.0 MODELLING APPROACH

2.1 Model Selection

Quantitative analyses of historical data, assessment of existing conditions, and evaluations of the potential future impacts of water management strategies depends on the application of a credible modelling platform. Consequently, selection of a model code was a key component in development of the North Saskatchewan River (NSR) model.

In selecting the appropriate model for the job, we applied a number of criteria including the following primary considerations:
- Can the model meet study goals?
- Is the model code (and related processing tools) in the public domain?

-        Is the model well-documented and supported by developers (long-term availability of documentation, expertise and technical support)?
-        Is the model widely-used and accepted for similar applications?
-        Can the model be easily tailored to Alberta conditions and issues?

A number of other operational factors were also considered, including:
-        ability to represent a broad parameter suite, including eutrophication-related parameters, metals, bacteria, etc.
-        capability of 2-dimensional modelling;
-        ability to process output data;
-        ability to customize or improve model;
-        capability to develop and maintain the model using in-house capacity

In consideration of the selection factors, a decision was made to set up a new model for the NSR/IH, building on previous modelling work of the City of Edmonton NSR (WASP) model (Golder, 2005) and on exploratory NSR modelling (WASP) by Alberta Environment (2007).

The Environmental Fluid Dynamics Code (EFDC) was selected as the framework for the NSR hydrodynamic and water quality model. EFDC can be programmed to be functionally equivalent to other common models such as WASP, and provides more flexibility in development (e.g., adjustable model grid). In addition, the model is designed to provide relatively easy linkage with "catchment" type models such as SWAT, HSPF, or LSPC. EFDC is one of the only currently supported public domain modelling systems that incorporates fully linked, user-transparent hydrodynamics, sediment transport, water quality and sediment diagenesis simulation capabilities.

Details of EFDC's hydrodynamic and eutrophication components are provided in Hamrick (1992) and Tetra Tech (2002, 2006a, 2006b, 2006c, 2006d). EFDC is a general purpose modelling package for simulating one-dimensional (1-D), two dimensional (2-D), and three-dimensional (3-D) flow, transport, and biogeochemical processes in surface water systems including rivers, lakes, reservoirs, and wetlands. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications. This model is now being supported by the U.S. Environmental Protection Agency (EPA) and has been used extensively to support Total Maximum Daily Load (TMDL) development throughout the United States. The model has been tested, documented, and applied to environmental studies by universities, government agencies, and environmental consulting firms (see references in USEPA, 2005, 2009).

In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near-field and far-field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases. Cohesive sediment refers to silt and clay particles, while non-cohesive refers to anything larger than silt (e.g., sand, gravel).

EFDC includes four primary models: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The hydrodynamic model predicts water depth, velocities, and water temperature. The water quality portion of the model uses the results from the hydrodynamic model to compute the transport of the water quality variables. The water quality model then computes the condition of up to 22 aquatic variables including dissolved oxygen, phytoplankton, benthic algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria (Cerco and Cole 1994). The sediment transport and toxics models use the hydrodynamic model results to calculate the settling of suspended sediment and toxics, resuspension of bottom sediments and toxics (e.g., metals), and bed load movement of noncohesive sediments and associated variables.

2.2   Model Enhancements

Ice Model

The NSR is covered with ice for about 5 to 6 months in a typical year. The original EFDC model code did not include the functionality to simulate hydrodynamic and water quality under ice covered conditions. The hydrodynamic and water quality components of the EFDC model have been modified to account for the effects of ice cover on flow resistance, heat transport, and water quality simulation using externally supplied ice cover information.

Time varying fractional ice cover can be input to the model for each cell. This data is read from an empirical data file (icecover.inp). If the value is 1, then water is covered with ice. If the value is 0, water is not covered with ice. For example, for a segment that is 80% is covered with ice, fractional ice cover will equal 0.8. Fractional ice cover information is used to block surface wind stress and define an under-ice flow resistance in the hydrodynamic component of the model.

The flow resistance (shear stress; τ_{ICE}) caused by ice is calculated as a function of U and V velocity components for each cell. To illustrate, this is commonly observed in rivers as ice forms initially in lower velocity zones; e.g., along banks and in backwaters. At present, the ice module does not represent the displacement effect of ice on water levels. In the heat transport model, fractional ice cover information is used to modify surface heat transfer changing from open-water transfer to fully ice-covered. Under full ice conditions, direct heat exchange between air and water is disabled. Attenuation of solar radiation transfer through ice is user-defined in the model as a proportion between 0 and 1. Water surface reaeration is also correspondingly reduced in response to fractional surface ice cover (area).

The model does provide functionality to calculate ice formation and decay based on air temperature and insolation; however, the present configuration is set to read user-defined daily ice cover for each cell. Due to data limitations for measured ice cover thickness, the input in the current NSR model configuration is designated as no cover or full cover for individual cells. However, future model calibrations will include fractional ice cover based on documentation of open leads.

2.3   Model Configuration

Model configuration involved setting up the model computational grid using available geometric data, designating the model's state variables, setting boundary conditions, and setting initial conditions. This section describes the configuration process and key components of the model in greater detail.   The Control File for the NSR model (efdc.inp) is shown in Appendix G.   There are a number of other relevant model input files (e.g., model grid; lxly.inp); because these are sizable with respect to text, they are not documented in this report.   The reader is referred to published EFDC manuals for description of model input files and their functions (TetraTech, 2002: a-d).   Electronic input files for this specific model are available from the authors.

2.3.1   Segmentation/Computational Grid Setup

The computational grid setup defines the process of segmenting the NSR into small computational segments for application of the model. A model grid system was developed for approximately 400 kilometers of the NSR between Devon and 38 kilometers below the Alberta-Saskatchewan border (Deer Creek Hydrometric Station 05EF001). The AENV model grid for the NSR is composed of two parts: a 2-D grid (with lateral variability) to represent the NSR from Devon to Pakan, and a 1-D grid to represent the NSR from Pakan to flow station 05EF001, which is approximately 38 kilometers downstream of the Alberta–Saskatchewan border (Figure 2-1). Model grid files were generated using the EFDC grid generator (Tetra Tech, 2002 a; b).
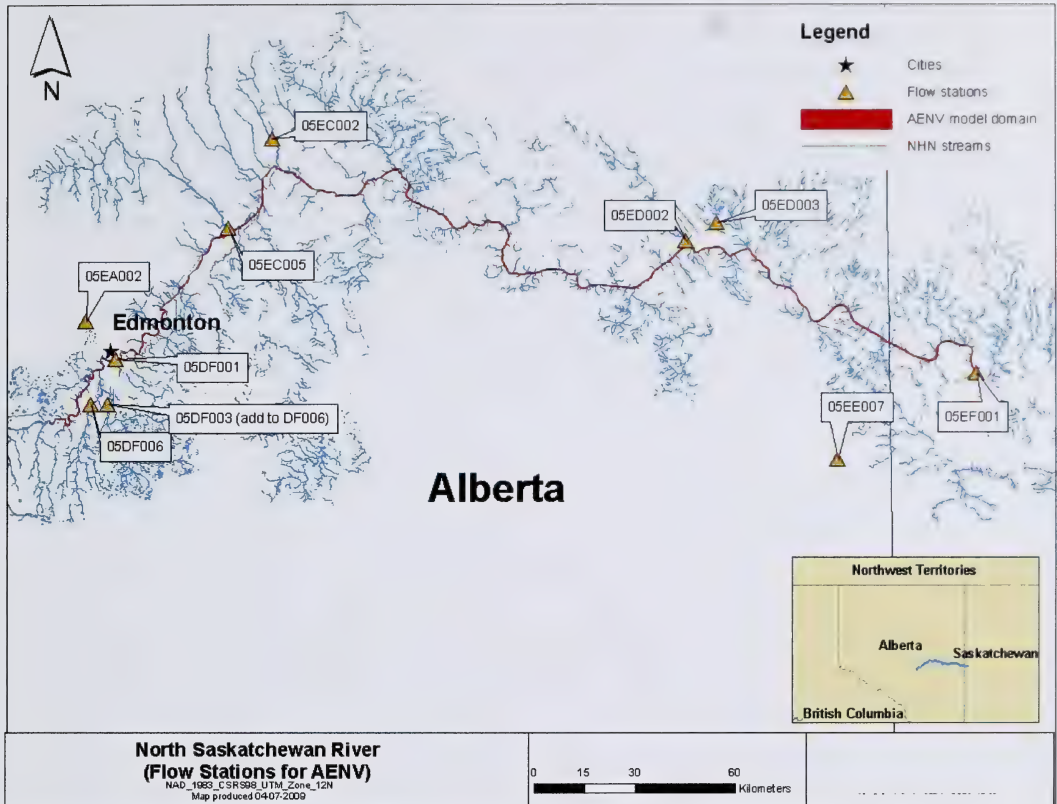
Figure 2-1. The AENV model domain of the NSR with flow stations on major tributaries and the mainstem.

The active model domain is comprised of 1,773 cells. To generate the grids, available NSR geographical information system (GIS) files were first edited, as the original GIS files included numerous details irrelevant to grid generation and were difficult to use directly. The river channel was then evenly divided into five lateral segments for the portion of the river from Devon to Pakan. Longitudinally, the segments are relatively long for the straight river reaches (up to 1,500 m) and quite a bit shorter for meandering reaches to more accurately represent spatial variability (down to 200 m). A total of 1,505 cells were generated for the 2-D portion of the NSR. The widths vary from 20 m to 70 m.

Downstream of Pakan, the model uses a 1-D grid, connected to the upstream grid. For the 1-D grid, the NSR was divided into segments with approximately 1,000-m lengths, based longitudinally on the channel mid-line. The average width was calculated using GIS for

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each segment. A total of 260 cells were generated for the 1-D section. Widths of the segments vary from approximately 50 m to 450 m. The width was adjusted to include only the waterway width for the river sections with islands. The connection between the 2-D and 1-D grids is composed of eight segments, which include four triangular cells.

In this report, grid numbers are notated as (I, J), where I increases from upstream to downstream, and J increases from the left to right bank (Figure 2-2). As noted above, 5 active lateral cells are defined in this model. Looking downstream, 4 denotes the far left cell; 8 denotes far right. This notation accommodates discreet boundary cells, as well as triangular cells representing the 2-D to 1-D model boundary.
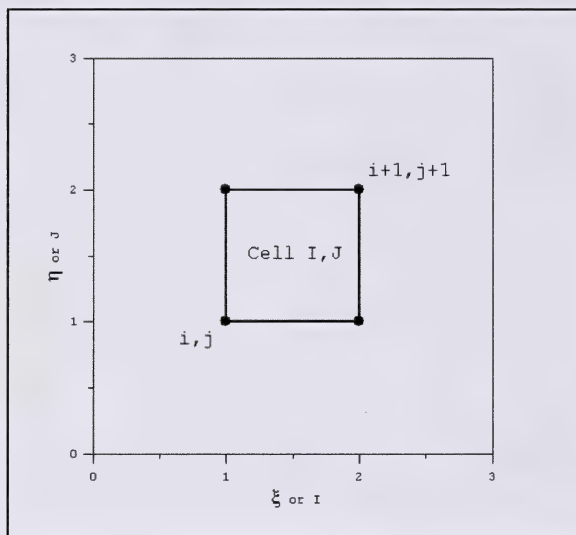
Figure 2-2. EFDC grid and cell notation.

The depth of each segment was determined to enable grid development. Sources of depth information that were used include:
- cross-section survey data and HEC-RAS model results from flood mapping studies, covering the reach from Devon through Fort Saskatchewan (~200 measured cross-sections; AENV, 2004 and 2007); and
- cross-section survey data for the river reach downstream of Fort Saskatchewan to near the Alberta-Saskatchewan border (~50 measured cross-sections; AENV, 1990).

The 2007 HEC-RAS cross-sections are in HECRAS input file format (USACE, 2002). Excel spreadsheet tools were developed to calculate the average depth of each cell. In the 2-D model domain, cross-sections are represented by 5 depths (5 cells) across the channel. For the 1-D sections, average cross-sectional depth is represented, as there is no lateral component to the physical model.

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The locations of the cross-sections were identified and digitized into ArcMap. Only hard copies of the 1990 cross-section data were available. The locations of these cross-sections were estimated using a map. The original depth data were in different formats; hence, average depths were estimated directly from the plots of the cross-sections on the hard copies. The locations of the 1990 cross-sections were positioned by comparing maps and satellite topographical data and digitized into ArcMap. Interpolation was performed for segments that were devoid of depth data. The segments without depth data from Devon to Fort Saskatchewan were interpolated using 2007 HEC-RAS model cross-section data. The segments without depth data from Fort Saskatchewan to station 05EF001 (Saskatchewan Border; Figure 2-1) were interpolated using the 1990 data. The entire modelling domain for the AENV model of NSR is shown in Figure 2-1, and a portion of the 2-D model grid for the NSR is shown in Figure 2-3. Figure 2-4 shows a segment of the NSR with relevant flood risk mapping data. Figure 2-5 shows a portion of the 1-D model grid. Figure 2-6 shows the bed elevation for selected reaches along the model domain.
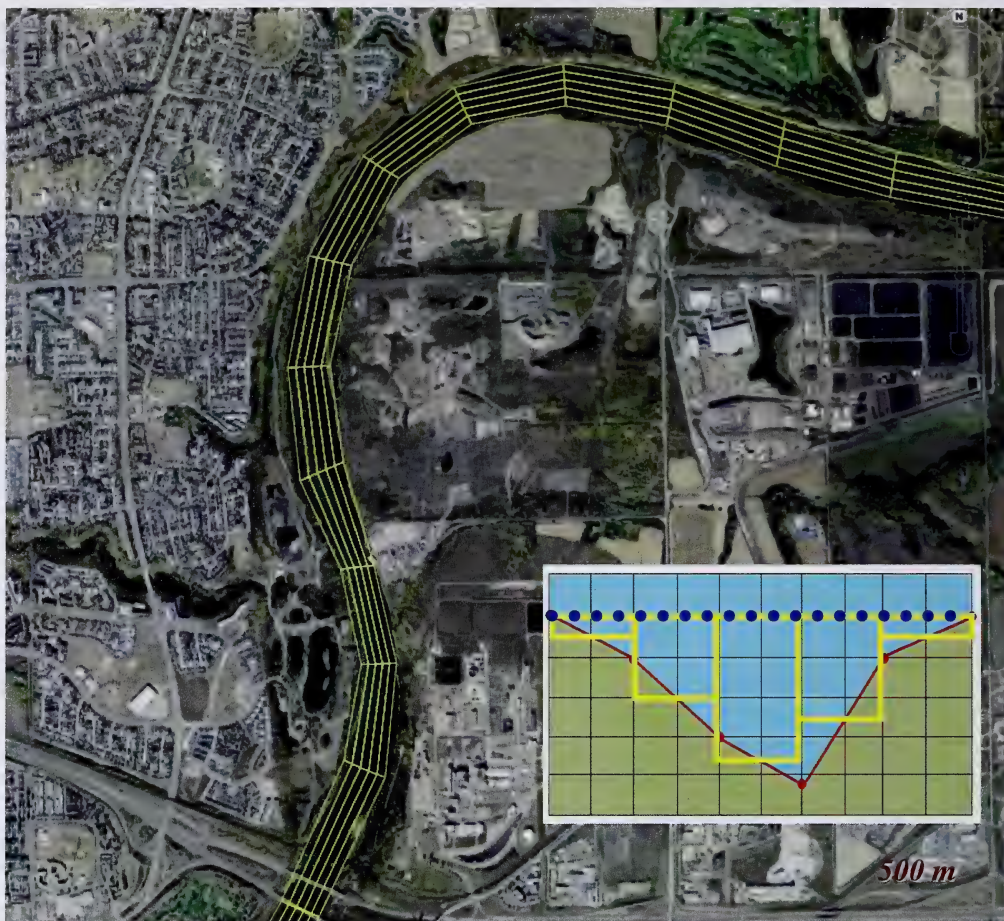
Figure 2-3. A portion of the 2-D grid for the AENV NSR model (East Edmonton area; inset illustrates a generic cross-section).

Figure 2-4. Flood risk map of NSR section showing survey and contour information.

Figure 2-5. A portion of the 1-D grid for the NSR model (downstream of Pakan – Hwy 855).
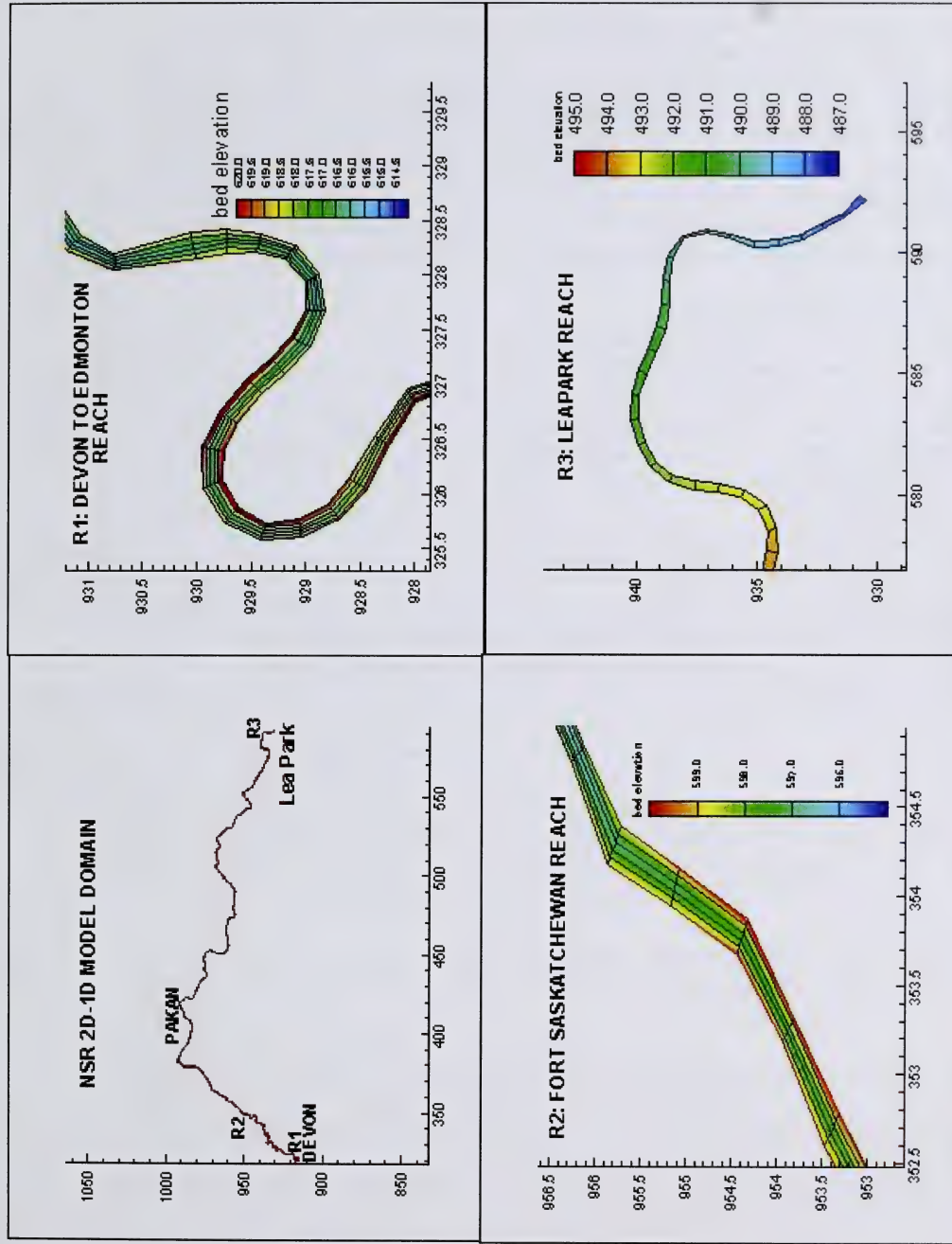
Figure 2-6. Bed elevation for selected reaches in the NSR model domain (x and y axes indicate map coordinates).

2.3.2   *State Variables*

State variables are parameters that contain enough information about a system's history to enable computation of its future behavior; these variables are used in model computations to describe the "state" of a system.   Selecting appropriate model state variables to represent water quality processes of concern is a critical factor in model configuration. For this study, state variables were selected to most accurately predict dissolved oxygen, organic carbon, and nutrients under the influence of tributaries, WWTPs, WTPs, industrial facilities, CSOs, and storm water. The following state variables are configured in the present NSR EFDC eutrophication model, as illustrated in Figure 2-7.   Other variables will be discussed in a subsequent report (e.g., physical chemistry).

1. Phytoplankton (one group)
2. Refractory particulate organic carbon (RPOC)
3. Labile particulate organic carbon (LPOC)
4. Dissolved organic carbon (DOC)
5. Refractory particulate organic phosphorus (RPOP)
6. Labile particulate organic phosphorus (LPOP)
7. Dissolved organic phosphorus (DOP)
8. Orthophosphate (PO4)
9. Refractory particulate organic nitrogen (RPON)
10. Labile particulate organic nitrogen (LPON)
11. Dissolved organic nitrogen (DON)
12. Ammonia (NH3)
13. Nitrate (NO2/NO3)
14. Dissolved oxygen (DO)
15. Benthic algae
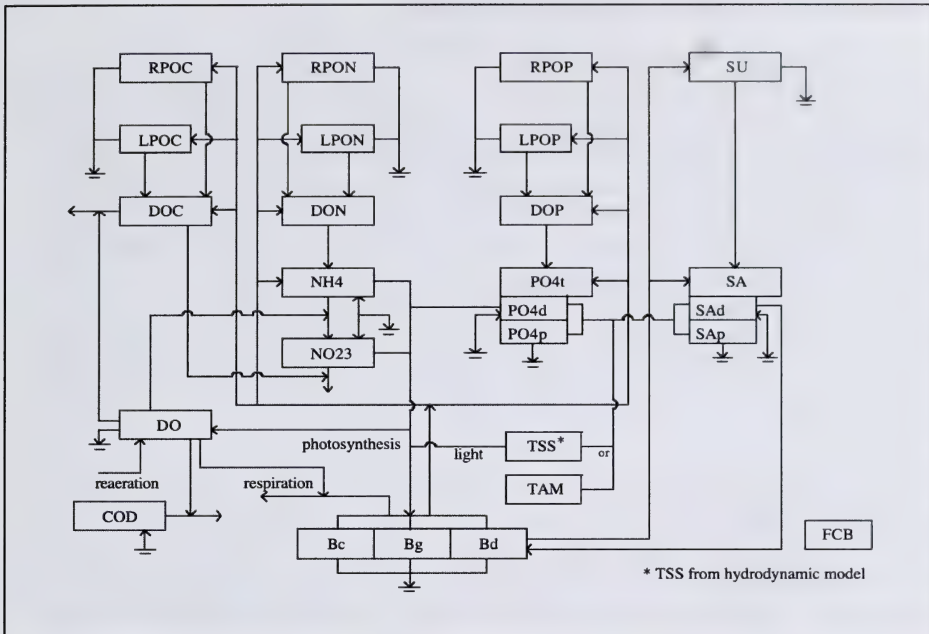
Figure 2-7. **Model overview: EFDC water quality schematic. See Tetra Tech (2002)**
for definition of terms (e.g., RPOC: refractory particulate organic
carbon; LPOC: labile particulate organic carbon).

2.3.3   *Boundary Conditions*

To run the NSR model, external forcing factors (boundary conditions) must be specified
for the system. These forcing factors are a critical component in the modelling process
and have direct implications on the quality of the model's predictions. External forcing
factors include a wide range of dynamic information, including:

• Upstream boundary conditions: upstream inflows, temperature, and water quality;
• Tributary (or lateral) inflow boundary conditions: tributary inflows, temperature, and
water quality;
• Loadings from point sources;
• Surface boundary conditions: atmospheric conditions (including wind, air temperature,
solar radiation); and
• Downstream boundary conditions (to enable mass balance with terminal cell output).

Boundary conditions are discussed in more detail in the following sections.

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2.3.3.1   *Upstream Boundary Conditions*

Upstream inflows represent the inflow at the model's starting point. The model starts at Devon on the NSR. However, there is no flow station at this location. The upstream inflow rates were determined from the hourly flow measured at Edmonton on the NSR and on tributaries, including Blackmud Creek and Whitemud Creek. The flow at Edmonton can be considered as the total NSR flow at Devon and from relevant tributaries. Therefore, the flow at Devon was calculated using the flow at Edmonton and subtracting flow from the two tributaries. Water temperature was not measured at this location. The continuous (datasonde) water temperature data recorded at the Devon station were averaged on a hourly basis, and these were used as the upstream temperature boundary condition. For water quality simulations, the input loading values for all state variables (excluding periphyton) are needed. Water quality information is available at the Devon water quality station, which is approximately 3 kilometers below the upstream boundary location.

The water quality data for Devon were processed in order to generate the loading time series required for EFDC. Water quality parameters include NH3, DOC, TOC, NO2/NO3, chlorophyll a, total Kjeldahl nitrogen (TKN), DO, total phosphorus, and dissolved phosphorus. Some of the water quality data were below the detection limit; in these cases, 50 percent of the detection limit was used as the concentration. Carbon and nutrient data were converted to EFDC state variables; to facilitate this, an Excel spreadsheet tool was developed to (1) calculate loadings from the water quality data using measured flow data, (2) convert carbon and nutrients to the EFDC state variables, and (3) output data in the EFDC water quality boundary file format. Because of limited available data, the conversion to EFDC state variables was conducted based on review of literature values and documentation from other EFDC applications (e.g., USEPA 1985, 1997, & 2000). Conversions applied in this model are presented in Table 2-1.

Table 2-1. Conversion of water quality data to EFDC state variables.

EFDC state variables	Conversion from water quality data
Refractory particulate organic carbon (RPOC)	(TOC – DOC) × 0.5
Labile particulate organic carbon (LPOC)	(TOC – DOC) × 0.5
Dissolved organic carbon (DOC)	DOC
Refractory particulate organic phosphorus (RPOP)	(TP – TDP) × 0.5
Labile particulate organic phosphorous (LPOP)	(TP – TDP) × 0.5
Dissolved organic phosphorous (DOP)	TDP × 0.5
Orthophosphate (PO4)	TDP × 0.5
Refractory particulate organic nitrogen (RPON)	(TKN – Ammonia) × 0.3
Labile particulate organic nitrogen (LPON)	(TKN – Ammonia) × 0.3
Dissolved organic nitrogen (DON)	(TKN – Ammonia) × 0.4

2.3.3.2   *Tributary Boundary Conditions*

Tributary inputs to the model encompass the major tributaries that feed into the NSR. Flow, temperature, and water quality data were also required for these inputs to the river. Table 2-2 shows the eight tributaries included in the model, from the upstream boundary to the downstream boundary location. A flow balance analysis was conducted from Edmonton to Deer Creek flow station (05EF001) on the NSR. The total flow from 2000 to 2007 at Deer Creek was higher than the total flow from Edmonton and the tributaries, implying that flow from the drainage area was not fully represented by the tributaries used in the model. To ensure flow balance, the total flow from the tributaries was increased to represent the tributaries not explicitly included between Edmonton and Deer Creek flow station (05EF001), as shown in Table 2-2.

Table 2-2. Tributaries included in the NSR model.

ID	Tributary Name	Flow Station	Flow Adjustment	EFDC Grid ID
1	Blackmud Creek	05DF003	1	8, 79
2	Whitemud Creek	05DF006	1	8, 79
3	Sturgeon River	05EA002	5.17	4, 190
4	Redwater River	05EC005	5.17	4, 220
5	Waskatenau Creek	05EC002	5.17	4, 267
6	Atimoswe Creek	05ED002	5.17	4, 446
7	Moose Hill Creek	05ED003	5.17	8, 468
8	Vermilion River	05EE007	5.17	8, 500

Water temperature data are also required for the tributaries. Water temperature was not measured on the tributaries at consistent time intervals. Therefore, water temperature used for the tributaries is the same as the upstream boundary water temperature. This is a combination of all available observed temperature data.

Nutrients, organic carbon, and dissolved oxygen data from the tributaries were needed for water quality simulations in the model. Monitoring data for the tributaries were compiled and reformatted to prepare for conversion to EFDC state variables. Concentration values from all tributaries over the entire sampling period were used; daily loading data for individual tributaries were derived from interpolation of discreet concentration measurements applied to daily flow data. Values for tributaries without measured data were estimated by averaging values for tributaries for which measured data exists (including the tributaries above the upstream boundary location). Water quality data used for model input include ammonia, DOC, TOC, nitrate, TKN, dissolved oxygen, total phosphorus, and dissolved phosphorus. In some cases, DOC values were reported higher than the TOC values, and the TOC values were reset to the DOC values. Some data were below the detection limit; in these cases, 50 percent of the detection limit was used as the

concentration. Carbon and nutrient data were converted to EFDC state variables as discussed in Section 2.3.3.1. The conversions are the same as those shown in Table 2-1.

2.3.3.3   *Point Sources*

A number of effluent (point source) discharges exist in the NSR watershed, particularly in the Edmonton – IH reach. The point sources include WTPs, WWTPs, industrial facilities, CSOs, and storm sewers. Figure 2-8 shows the locations of major dischargers in the Edmonton – IH area. Table 2-3 lists the names and relative locations of the point sources included in the model. Table 2-4 illustrates the variability of available information among dischargers.

The availability of information for water quality parameters differs substantially among dischargers. In addition, data for different point sources cover different time periods. The original data were compiled and processed; this included interpolating missing data and averaging of data reported for matching time periods. Effluent discharge data was compiled in a database from a number of sources, including:

- AENV Approvals Database;
- AENV Monitoring (e.g., synoptic and contaminant load studies – WDS database);
- City of Edmonton CSO/Storm outfall data inventories;
- Water Users Questionnaire, distributed by AENV 2008 to dischargers in the Capital Region / IH area – includes data on quantity, quality, location, timing, treatment, etc of withdrawals and wastewater discharge;
- previous NSR modelling studies by AENV and the City of Edmonton (Golder, 2005).

Available data did not exactly match EFDC water quality state variables. As a result, some data were converted to EFDC water quality state variables. Several assumptions were made to convert point source data into the appropriate format, based on literature values (e.g., USEPA, 1985 & 1997) and model documentation (Tetra Tech, 2006a). These include the following:

• Thirty percent of organic nitrogen was allocated to RPON; 30 percent of organic nitrogen was allocated to LPON; and 40 percent of organic nitrogen was allocated to DON.
• When no NH3 data were available for a discharger, TKN was converted to NH3 and organic nitrogen using the NH3/TKN ratio from other facilities.
• Total phosphorus was equally divided to PO4 and organic phosphorus.
• Thirty percent of organic phosphorus was allocated to RPOP; 30 percent of organic phosphorus was allocated to LPOP; and 40 percent of organic phosphorus was allocated to DOP.
• TOC and DOC measured by AENV at point sources where used wherever available and were deemed representative of the discharge.
• Where available from dischargers, COD/BOD ratios were used to derive a relationship for TOC (2.67 conversion).

• When no DOC data are available, TOC is converted to DOC and POC using the TOC/DOC ratio from other facilities.
• POC was derived by subtracting DOC from TOC. POC is then evenly divided into LPOC and RPOC.
• When BOD, COD, DOC, and TOC are all available, only DOC and TOC are used.
• Monthly averages were used to fill the time periods without data.
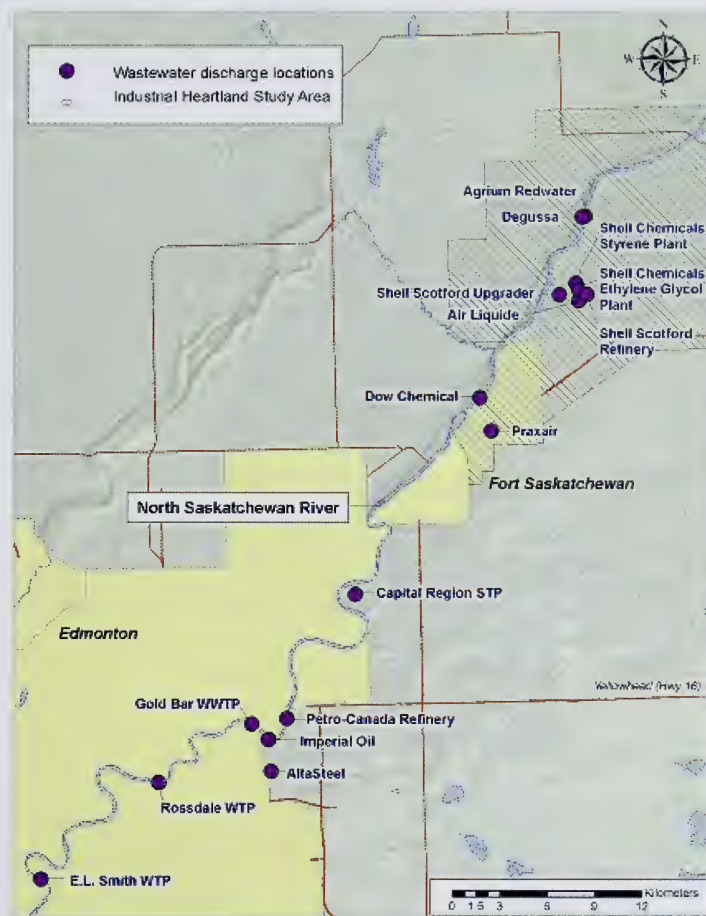
Figure 2-8. Locations of point source dischargers on the NSR in the Edmonton – IH reach.

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Table 2-3. Point sources included in the EFDC model for the NSR.

Approval #	AENV Station No.	Name of Source	River distance from Devon (Km)	Bank Location (Looking downstream)
		Industrial		
18704	AB05EB1760	Raylo Chemicals Inc.	53.4	Right
1480	AB05EB1413	AT Plastics Inc.	55.9	Right
10192	AB05EB1440	Imperial Oil	55.9	Right
1408	AB05EB1391	Alta Steel Ltd.	56.4	Right
10184	AB05EB1650	Petro-Canada Products	57.8	Right
98	AB05EB1740	Owens-Corning Canada Inc. - Wastewater	59.5	Right
98	AB05EB1741	Owens-Corning Canada Inc. - Sanitary sewage	59.5	Right
1234	AB05EB1780	Celanese Canada Inc. South Flume Effluent	60	Right
1349	AB05EB1800	Celanese Canada Inc. North Flume Effluent	60	Right
211	AB05EB1990	Viridian Fort Saskatchewan	83.8	Right
229594	AB05EB2582	Gulf Chemicals - Effluent "A" Discharge	84.3	Right
237	AB05EB2150	Dow Chemical Canada Inc. - Ft. Sask. Chemical Plant	90.4	Right
68179	AB05EB4661	Air Liquide Scotford	98.8	Right
59	AB05EB2630	Shell Canada Limited - Scotford Refinery	98.8	Right
9767	AB05EB2660	Shell -Styrene Monomer (SM) plant discharge	98.8	Right
9767	AB05EB2673	Shell -Ethylene Glycol (MEG) plant discharge	98.8	Right
194	AB05EB2580	Geon Canada Inc.	99.2	Right
49587	AB05EB4732	Scotford Upgrader Clean Stormwater Pond Release	99.2	Right
49587	AB05EB4731	Scotford Upgrader Effluent Pond Discharge	99.2	Right
210	AB05EB2950	Agrium Redwater	104.1	Left
1034	AB05EB2930	Degussa Canada Inc. Gibbons	104.1	Right
		Municipal		
601	AB05DF0350 & AB05DF0480	Devon Sewage Treatment Plant	0.5	Right
-	NA	ELSmith WTP	27.6	Left
639	NA	Edmonton - Wedgewood Ck	35.5	Left
639	AB05EB3190	Edmonton - Quesnell Storm Sewer	36.5	Left
639	NA	Edmonton - Whitemud Ck	36.5	Right
639	NA	Edmonton- 30th Avenue Storm	38.6	Left
639	NA	Edmonton - Belgravia	38.6	Right
639	NA	Edmonton - Capilano CSO	38.6	Right
639	AB05EB3200	Edmonton - Groat Road Storm Sewer	42	Left
-	NA	Rossdale WTP	45.4	Left
639	NA	Edmonton - Mill Creek	47.8	Right
639	NA	Edmonton - Rat Creek CSO	49.8	Left
639	NA	Edmonton - Highland CSO	51.8	Left
639	NA	Edmonton - Remaining CSO	51.8	Left
639	AB05EB3460	Edmonton Gold Bar Sewage Treatment Plant	54.5	Right
639	AB05EB3240	Edmonton - Kennedale Storm Sewer	60.4	Left
639	NA	Edmonton - Horse Hill Ck	70.8	Left
486	AB05EB3140 & AB05EB3530	Capital Region Sewage Treatment Plant	72.5	Right
-	NA	Elkpoint WWTP	305	Left

Table 2-4. Available information from dischargers included in the EFDC model for the NSR.

Facility Name	Begin Date	End Date	Flow	NH3	NO23	Org N	TKN	PO4	TP	BOD	COD	DOC	TOC	Reference
Municipal Water Treatment Plants														
EL SMITH	1/1/2000	6/30/2008	Y	Y	Y		Y		Y					Provided Email and data from 2008/2009 AENV Questionnaire
Rossdale	1/1/2000	6/30/2008	Y	Y	Y		Y		Y					Provided Email and data from 2008/2009 Survey
Municipal Wastewater Treatment Plants														
Devon WWTP	1/1/2000	5/31/2008	Y	Y						Y				Provided by the Town of Devon
Capital Region WWTP	1/1/2000	6/30/2008	Y	Y						Y				Provided by Capital Region WWTP; AENV Questionnaire
Gold Bar WWTP	1/1/2000	12/31/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton; 2008/2009 AENV Questionnaire
Gold Bar WWTP (Combined By pass)	1/1/2000	12/31/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton; 2008/2009 AENV Questionnaire
Elk Point WWTP	1/1/2000	12/31/2008	Y							Y				Provided by the Town of Elk Point
CSOs and Storm Sewers														
Rat Creek CSO	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Highland CSO	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Capilano CSO	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Remaining CSO	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
30th Avenue Storm	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Groat Rd Storm	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Quesnell Storm	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Kennedale Storm	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Whitemud Ck	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Horse Hill Ck	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Wedgewood Ck	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Belgravia	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Mill Creek	1/1/2000	6/30/2008	Y	Y	Y		Y		Y	Y				Provided by the City of Edmonton
Industrial														
ALTASTEEL LTD.	1/1/2000	4/30/2008	Y	Y								Y		WDS (AENV); 2008/2009 AENV Questionnaire
PETRO-CANADA PRODUCTS	1/1/2000	4/29/2008	Y	Y								Y		WDS (AENV); 2008/2009 AENV Questionnaire
OWENS-CORNING CANADA INC.	1/1/2000	2/29/2004	Y	Y				Y	Y		Y			WDS (AENV); 2008/2009 AENV Questionnaire
OWENS-CORNING CANADA INC.	1/1/2000	2/29/2004	Y	Y										WDS (AENV); 2008/2009 AENV Questionnaire
VIRIDIAN FT. SASK	1/1/2000	1/10/2000	Y	Y	Y	Y		Y		Y	Y			WDS (AENV); 2008/2009 AENV Questionnaire
GEON CANADA INC. - SCOTFORD	1/1/2000	3/30/2006	Y	Y	Y			Y		Y	Y		Y	WDS (AENV); 2008/2009 AENV Questionnaire
SHELL CANADA PRODUCTS LTD. - SCOTFORD	1/4/2008	4/28/2008	Y	Y							Y			WDS (AENV); 2008/2009 AENV Questionnaire
SHELL CANADA PRODUCTS LTD. - SCOTFORD REFINERY	1/5/2008	3/26/2008	Y							Y	Y			WDS (AENV); 2008/2009 AENV Questionnaire
DEGUSSA CANADA INC. - GIBBONS	1/1/2000	4/30/2008	Y	Y	Y	Y		Y		Y	Y	Y	Y	WDS (AENV); 2008/2009 AENV Questionnaire
AGRIUM - REDWATER	1/1/2000	5/31/2008	Y	Y	Y	Y				Y	Y	Y	Y	WDS (AENV); 2008/2009 AENV Questionnaire
AT PLASTICS INC.	4/6/2000	5/22/2008	Y	Y						Y	Y		Y	WDS (AENV); 2008/2009 AENV Questionnaire
AT PLASTICS INC.	5/16/2000	5/8/2007	Y	Y							Y			WDS (AENV); 2008/2009 AENV Questionnaire
IMPERIAL OIL	1/1/2000	5/31/2008	Y	Y							Y			WDS (AENV); 2008/2009 AENV Questionnaire
RAYLO CHEMICALS INC.	1/1/2000	7/31/2000	Y				Y				Y			WDS (AENV); 2008/2009 AENV Questionnaire
CELANESE CANADA INC.	1/1/2000	11/14/2003	Y								Y			WDS (AENV); 2008/2009 AENV Questionnaire
CELANESE CANADA INC.	1/1/2000	12/9/2002	Y								Y	Y		WDS (AENV); 2008/2009 AENV Questionnaire
DOW CHEMICAL CANADA INC.	1/2/2000	4/30/2008	Y	Y					Y	Y	Y			WDS (AENV); 2008/2009 AENV Questionnaire
GULF CHEMICAL PROCESSING - FT. SASKATCHEWAN	3/30/2007	10/1/2007	Y										Y	WDS (AENV); 2008/2009 AENV Questionnaire
GULF CHEMICAL PROCESSING - FT. SASKATCHEWAN	4/4/2007	10/1/2007	Y											WDS (AENV); 2008/2009 AENV Questionnaire
SHELL CANADA PRODUCTS LTD. - SCOTFORD	1/3/2000	12/28/2006	Y				Y						Y	WDS (AENV); 2008/2009 AENV Questionnaire
SHELL SCOTFORD ETHYLENE GLYCOL PLANT	7/2/2000	12/31/2006	Y				Y			Y	Y		Y	WDS (AENV); 2008/2009 AENV Questionnaire
AIR LIQUIDE SCOTFORD	5/1/2000	5/31/2008	Y					Y			Y		Y	WDS (AENV); 2008/2009 AENV Questionnaire
SCOTFORD UPGRADER EFFLUENT POND DISCHARGE	9/23/2002	4/30/2008	Y	Y						Y	Y		Y	WDS (AENV); 2008/2009 AENV Questionnaire
SCOTFORD UPGRADER CLEAN STORMWATER POND RELEASES	10/3/2002	3/2/2003	Y	Y							Y			WDS (AENV); 2008/2009 AENV Questionnaire

2.3.3.4   *Surface Boundary Conditions*

The surface boundary conditions for the model domain are determined by the meteorological or atmospheric conditions and include air temperature, dew point temperature, pressure, wind speed, wind direction, and cloud cover. Four weather stations were used to determine surface boundary conditions for the EFDC model (Figure 2-9). Atmospheric data were processed and used to create atmospheric thermal interaction and wind forcing files. The wind file includes information on wind speed and direction. The atmosphere file includes air pressure, air temperature, relative humidity, precipitation, solar radiation, and cloud cover. The model segments are divided into four sections to use the data from those four weather stations. The general rule for assigning data to the model segments is to use the midpoint of two adjacent weather stations as the break point. Several assumptions were made to convert the observation data to EFDC input files:

• All missing flags (M) or blank fields were replaced using the previous hour observed for all parameters.
• Gaps in atmospheric pressure were filled using constant pressure values estimated from altitude.
• Gaps in weather descriptions were filled using the Edmonton station. The Lloydminster or Rocky Mountain House stations were also used, as necessary.
• The cloud cover description from the weather description was initially interpreted in the following way:
  >   Clear = 0.25
  >   Mainly Clear = 0.5
  >   Mostly Cloudy = 0.75
  >   Cloudy = 0.95
  >   All other descriptions (which seemed to be related to rainy conditions) = 0.9

The water temperature calibration was optimized by calculation of diffuse solar radiation using Bird's model (Bird & Hustrom, 1981). The Bird model uses site coordinates (e.g., latitude) along with other parameters to compute diffuse solar radiation. Specified parameters include:
 - Water (Wt): amount of precipitable water in a vertical column (est. from rel. humidity, temperature, pressure); and
 - Ground albedo: averaged over large-scale area, defines ground reflection.
 - Air mass: (estimated from pressure).

Figure 2-9. Weather station locations.

2.3.3.5 *Downstream Boundary Conditions*

In addition to the boundary conditions that specify input of water, heat, and water quality constituents, the model needs to know how water, heat, and water quality constituents leave the model domain. The downstream water quality in river systems typically will not affect the upstream portion, because water flows in one direction only (assuming that backwater effects are localized and minimal). The required downstream boundary conditions are related to outflow. Two approaches can be used for specifying the downstream outflow condition. One is to use observed flow data. The other is to use a stage-discharge curve. Both of these approaches were tested, and it was found that the stage-discharge approach generated better results. Therefore, the stage-discharge approach was used in the model. The observed water elevation and flow rates at Deer Creek station were used to derive the stage-discharge curve. Only data for open-water conditions were used. The derived curve is shown in Figure 2-10.
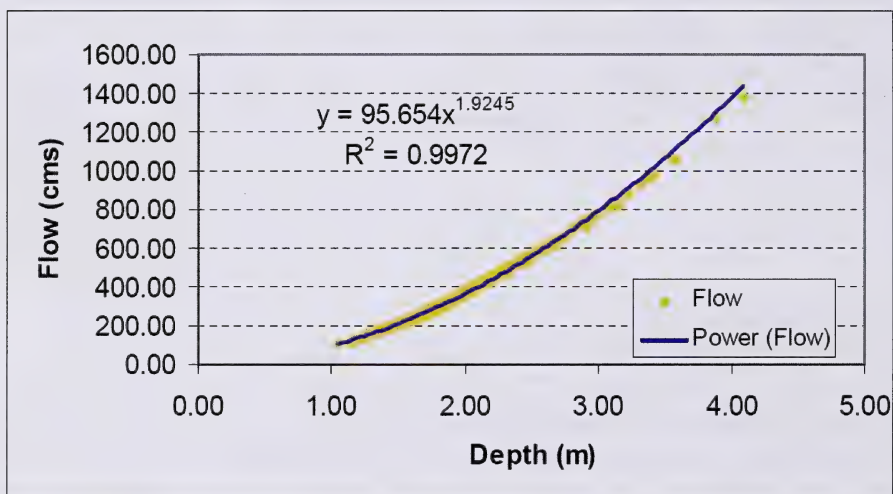
Figure 2-10. Stage-discharge curve derived from data measured at Deer Creek hydrometric station (d/s Saskatchewan Border).

2.3.4 *Initial Conditions*

The NSR model required specifying initial conditions in the input files. The EFDC model allows constant or spatially varying initial conditions for all model state variables. Parameters used to establish initial conditions include measured water temperature, elevation, and concentrations of other water quality constituents. NSR's water residence time is short, and the effect of the initial conditions disappears quickly. When the model runs, the boundary conditions quickly change the values from the initial conditions. Therefore, the initial conditions were set to ensure stable running of the model, especially

the hydrodynamics module. The most important step was to set the initial water surface elevation, which was assumed to be approximately parallel to the bottom elevation.

2.4 Modelling Assumptions, Limitations, and Sources of Uncertainty

All mathematical water quality models are a simplified representation of the complex real world, and the NSR model is no exception. It is important to identify critical assumptions and limitations regarding the model's predictive capability and applicability.

2.4.1 Assumptions

Major underlying assumptions associated with the present NSR model application are as follows:
• Complete mixing is assumed for each model cell;
• The impact of sediment transport and deposition on channel geometry is not significant; hence, the same bathymetric configuration can be used for all model simulations;
• All the organic matter in the water column has the same stoichiometric ratio;
• The impact of zooplankton and related factors is inherent in related rates for algal dynamics and nutrient recycling; and
• Field data are reliable for calibration.

2.4.2 Limitations

The limitations of the model are associated, in part, with model assumptions (above). Other factors that limit model capacity include the following:
• The present NSR model does not simulate multiple species of phytoplankton and benthic algae. Therefore, the model is presently limited in its capacity to evaluate competition among multiple species or seasonal succession of aquatic algal communities. Also, macrophytes are not presently represented. Work is underway, to resolve this issue in future model iterations.
• Benthic invertebrates are not presently simulated; this could add some uncertainty in the simulation of algal dynamics and nutrient cycling.
• Averaged depth across model cells limits the best simulation of benthic algae distribution, which is highly related to local variability in bottom solar radiation. This is resolved somewhat in the 2-D model, which includes 5 active cells across the channel. Less resolution is available in the 1-D model segments.
• Ice conditions are specified externally. It is sufficient for diagnostic purposes, though it is limited with respect to predicting conditions.
• The spatial scale of the model is large given the spatial resolution is approximately 500 to 1,000 m long. This can result in long simulation (computing) times, particularly over multiple years.
• The model is not suitable for detailed simulation for localized phenomenon with spatial scale less than the cell length and width, such as very near-field analysis of discharge plumes. A plume dispersion model (CORMIX) will be applied as needed to define near-field plume distribution.

2.4.3   *Sources of Uncertainty*

Boundary conditions are a primary source of uncertainty in the model. Because limited data were available for tributaries and point source discharges, interpolation and averaging were applied to estimate missing, incomplete, and multiple data. The temporal resolution of the simulation is higher than many of the boundary condition data sets. To illustrate, weather data are on an hourly scale; flows from the tributaries are typically defined as daily. Loading estimates for tributaries included all available data to calculate averages (Section 2.3.3.2). For point sources, loading data are available at inconsistent and irregular periods. In addition, some monitored water quality data had to be converted into EFDC state variables using constant conversion rates (Section 2.3.3.1).

3.0   MODEL TESTING

Once the NSR model was configured, model testing and calibration were performed, and remain ongoing. Model testing is often carried out in two steps—calibration and validation.

Calibration refers to adjusting or fine-tuning the modelling parameters to produce an adequate fit of the simulated output to the field observations. The calibrated model is then used to simulate an independent period for which field data under different environmental conditions are available for comparison. This is known as validation. For the validation run, most model process controlling parameters, except those for which field measurements are available, are held at values used during model calibration. Results of the validation run are then compared with field data for the same time period, and a decision is made as to whether predictions and observations are close enough to consider the model valid for predictive purposes. If validation results are not adequately close, the model process controlling parameters are adjusted accordingly, and the calibration and validation process is repeated. This is done iteratively until the results are adequate to consider the model valid for predictive purposes.

Ideally, calibration should involve multiple data sets encompassing as many variations and extremes as possible in the prototype. A model's ability to reproduce prototype behavior under a variety of conditions gives the modeler more confidence in the model's ability to accurately simulate the prototype under proposed conditions. If a model does not reproduce observed data (more importantly, trends in data) for a "verification" data set, then better results may be achieved through adjustment of coefficients, review of model assumptions, and inclusion of new processes to adequately match both sets of data. The separation of calibration and verification is arbitrary, and often, iterative model calibration to additional sets of data improves the fit to the first.

Our approach, following the practice increasingly adopted through the modelling community, is to model all the years continuously. This eliminates the separation of calibration and verification years or data sets. The NSR model simulates all conditions from 2000 to 2007. Because the period covers a range of conditions, it was deemed

appropriate to combine calibration and validation. That is, all available data were used to support model calibration for the entire period. This approach inherently considers validation because the model is optimized for the entire range of available data. Because the model reproduces a wide variation in prototype behavior encompassing numerous years, more confidence can be placed in its ability to reproduce behavior for the "right" reasons, than if the model were calibrated for one year and verified for another year.

The sequence of calibration for the NSR model involved calibrating hydrodynamic and heat transport first, and then calibrating water quality using available monitoring data. The model simulated hydrodynamics and water quality for September 2000 to January 2008. The four months in 2000 are considered as model "spin-up" period and were not included in the model calibration.

3.1 Supporting Data and Monitoring Locations

A significant amount of in-stream data is required to conduct model calibration. Available NSR in-stream data include water surface elevation, continuous (datasonde) water temperature, conductivity, and dissolved oxygen, as well as discrete (grab) sample results of water quality constituents. Water surface elevation and continuous water temperature data were used to calibrate the hydrodynamics and heat transport simulation. Continuous dissolved oxygen and other water quality data (e.g., discrete samples) were used for water quality calibration. Calibration was performed at multiple locations throughout the system. Table 3-1 lists the locations of the monitoring sites with continuous dissolved oxygen and temperature data as well as the EFDC grid IDs. Tables 3-2 and 3-3 list the years with temperature and dissolved oxygen data for the continuous monitoring sites. Table 3-4 lists the monitoring sites for the grab samples and the corresponding EFDC grid IDs. Figure 3-1 shows the monitoring locations on the NSR.

Table 3-1. Monitoring locations for continuous dissolved oxygen and temperature data.

Site locations	EFDC Grid ID
NSR at Devon	8, 12
NSR u-s Capital region WWTP	8, 153
NSR at Fort Saskatchewan Boat Launch	8, 175
NSR at Hwy 15 Bridge	4, 178
NSR u-s of Ft. Sask RR Trestle	8, 187
NSR d-s of Ft. Sask RR Trestle	8, 188
NSR at Vinca	8, 220
NSR at Pakan	4, 304
NSR at Lea Park	6, 499

Table 3-2. Years with continuous temperature data at monitoring locations.

Site Locations	2001	2002	2003	2004	2005	2006	2007
NSR at Devon	×	×	×	×	×	×	×
NSR u-s Capital region WWTP					×	×	×
NSR at Fort Saskatchewan Boat Launch					×	×	×
NSR at Hwy 15 Bridge			×	×			
NSR u-s of Ft. Sask RR Trestle	×						
NSR d-s of Ft. Sask RR Trestle	×						
NSR at Vinca				×	×		×
NSR at Pakan	×	×	×	×	×	×	×
NSR at Lea Park		×	×	×			

Table 3-3. Years with continuous dissolved oxygen data at monitoring locations.

Site Locations	2001	2002	2003	2004	2005	2006	2007
NSR at Devon	×	×	×	×	×	×	×
NSR u-s Capital region WWTP					×	×	×
NSR at Fort Saskatchewan Boat Launch					×	×	×
NSR at Hwy 15 Bridge			×	×			
NSR u-s of Ft. Sask RR Trestle	×						
NSR d-s of Ft. Sask RR Trestle	×						
NSR at Vinca				×		×	×
NSR at Pakan	×	×	×	×	×	×	×
NSR at Lea Park		×	×	×			

Table 3-4. Monitoring locations for grab samples used in water quality calibration.

Site Locations	EFDC Grid ID
NSR at DEVON	8, 12
NSR at ANTHONY HENDAY	6, 52
NSR at WALTERDALE	6, 98
NSR at 50 STREET	6, 123
NSR at RUNDLE	6, 131
NSR upstream of FORT SASKATCHEWAN	6, 178
NSR at VINCA	6, 220
NSR at WASKATENAU	6, 265
NSR at PAKAN	6, 304
NSR at HWY17	6, 499
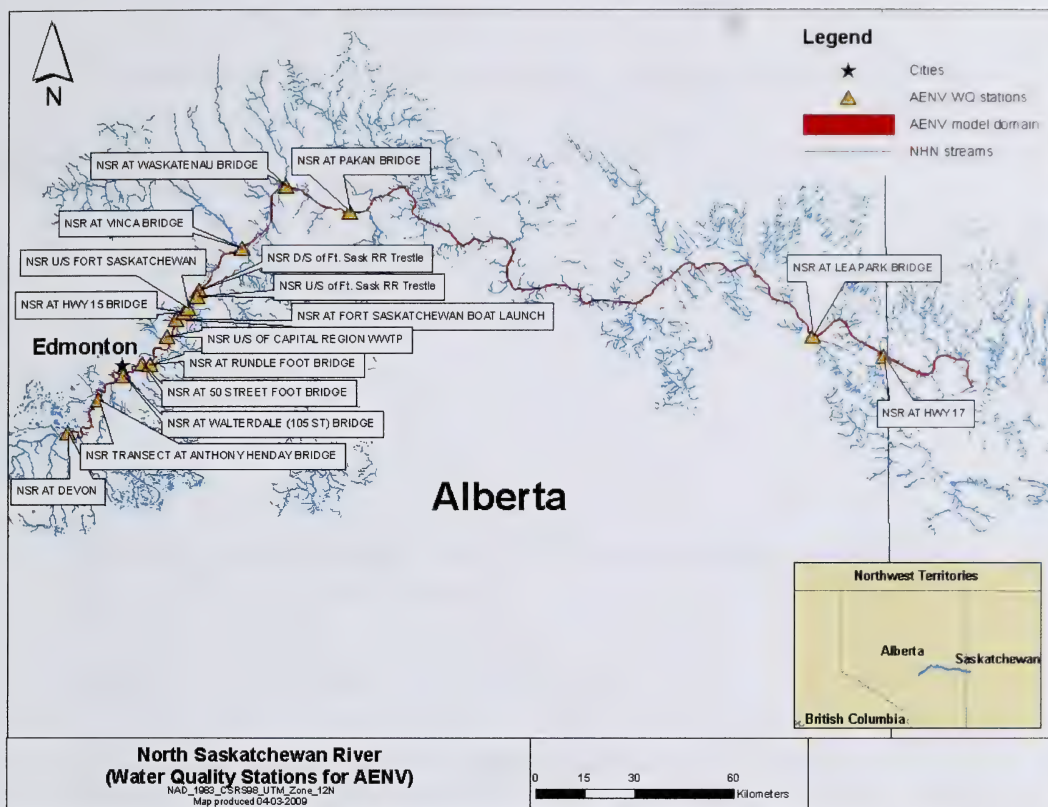
Figure 3-1. Calibration locations for NSR modelling.

3.2 Hydrodynamic Calibration and Validation

3.2.1 Water Surface Elevation

Water surface elevations were evaluated to ensure flow balance. Two flow stations are within the modelling domain (Edmonton and Deer Creek), and both of them have water surface elevation data available. The observed elevations were adjusted from the local datum to the sea level datum and then compared with modelled elevations. Figures 3-2 and 3-3 show the comparison of modelled and observed water surface elevations, typical of most years included in the calibration.

An important determination of adequate fit between modelled and observed data is whether the model is giving useful results based on model assumptions and input data. The NSR modelled elevations agree well with the observed elevations during open-water seasons (e.g., mean error of about 2 cm). In addition, travel times look reasonable based

on available low-flow dye study data (Section 3.2.2). Time series error measures for these two locations are shown in Table 3-5. Error measures are defined in Appendix B.

Table 3-5. Water surface elevation measurements compared with modelled data: error measures.

Location	Mean of observations (m)	Mean Error (m)	Relative Mean Error	Mean Absolute Error (m)	Relative Mean Absolute Error	Root Mean Square Error (m)
Edmonton - City Lt 53.5372; Lg 113.4855	614.18	0.015	0.00002	0.177	0.00029	0.308
Deer Creek Lt 53.5232; Lg 109.6179	489.81	0.018	0.00004	0.202	0.00041	0.348
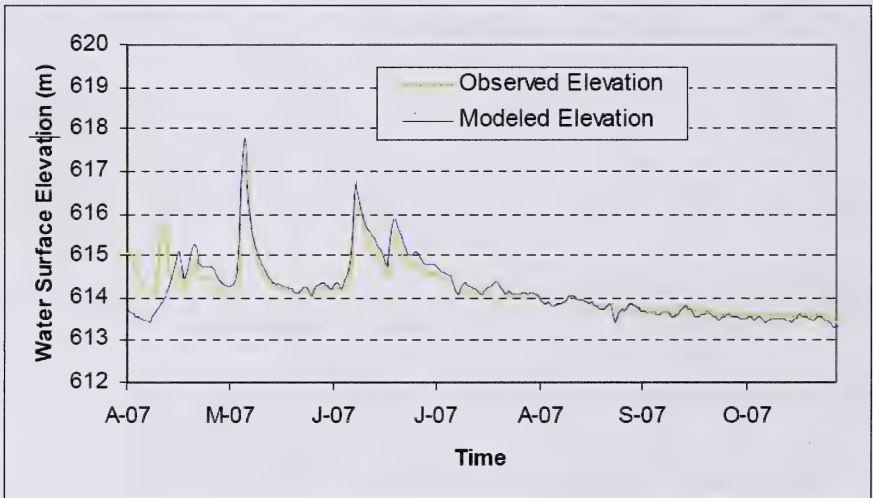
Figure 3-2. Modelled and observed elevations at the Edmonton flow station on the NSR.
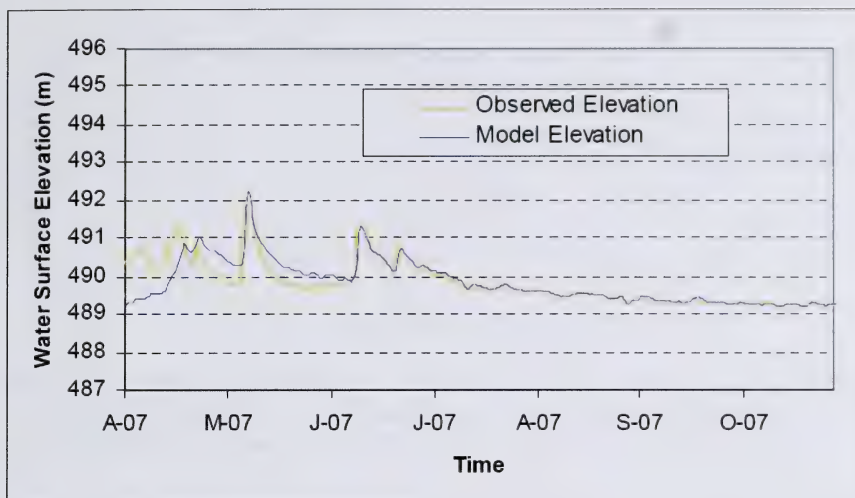
Figure 3-3. Modelled and observed elevations at the Deer Creek flow station on the NSR.

3.2.2 Longitudinal and Lateral Mixing

The capability of the model to simulate longitudinal and lateral transport was checked against two low-flow dye studies done sometime ago on the NSR. These include an open water tracer dye study done in October (Van Der Vinne, 1991a), and winter tracer dye study done in March (Van Der Vinne, 1991b). Calibration of transport for the 2D portion of the NSR model for the Devon to Pakan reach was based (in part) on measurements made available through these studies. Cross-channel measurements for this reach are available only from the open water flow study.

Lateral dispersion rates are represented in the EFDC model using kinematic eddy viscosity and eddy diffusivity coefficients. Matching of modelled dye concentrations with those from the dye studies at various locations downstream of Edmonton, indicates that values of $1E^{-6}$ m^2/s for minimum eddy viscosity and $1.4\ E^{-7}$ m^2/s for minimum eddy diffusivity are acceptable for carrying out water quality simulations (Figures 3-4 to 3-9).
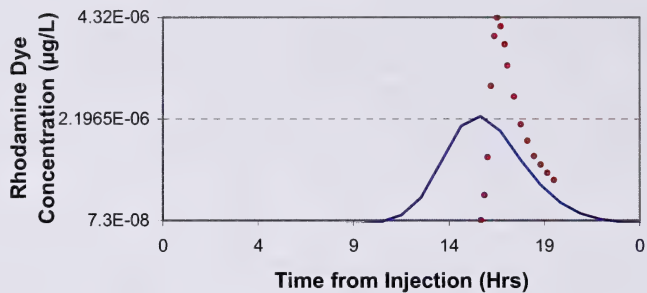
Figure 3-4. Simulated and observed concentrations of rhodamine dye at Fort Saskatchewan (Left Bank; solid line: modelled data; dots: field data).
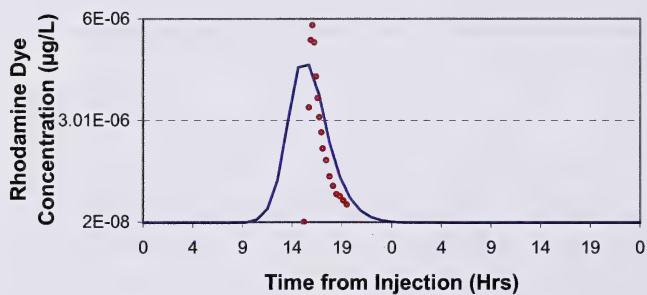
Figure 3-5. Simulated and observed concentration of rhodamine dye at Fort Saskatchewan (Center; solid line: modelled data; dots: field data).
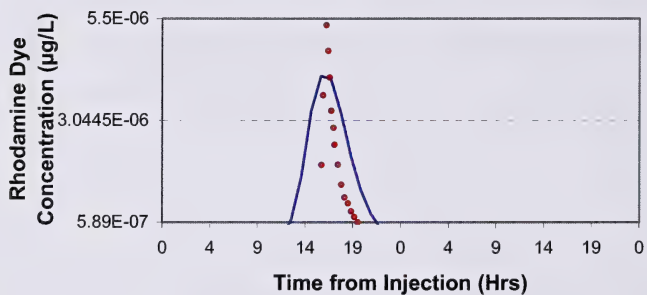
Figure 3-6. Simulated and observed concentration of rhodamine dye at Fort Saskatchewan (Right Bank; solid line: modelled data; dots: field data).
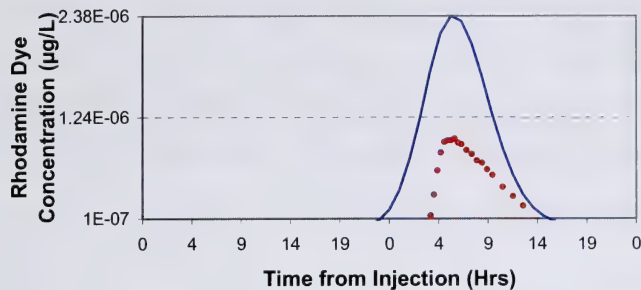
Figure 3-7. Simulated and observed concentration of rhodamine dye at Vinca (Left Bank; solid line: modelled data; dots: field data).
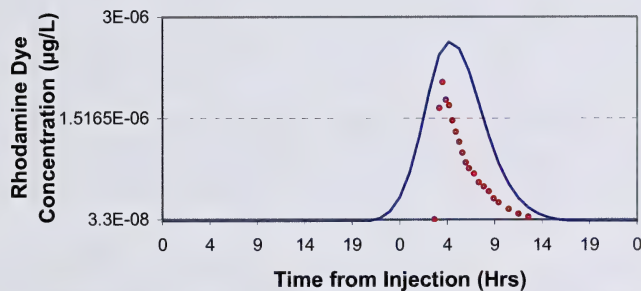
Figure 3-8. Simulated and observed concentration of rhodamine dye at Vinca (Center; solid line: modelled data; dots: field data).
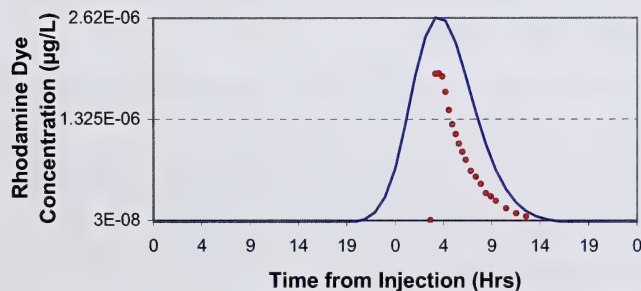
Figure 3-9. Simulated and observed concentration of rhodamine dye at Vinca (Right Bank; solid line: modelled data; dots: field data).

Modelled dye plume results show a broader leading edge, centroid and trailing edge compared to measured values. Modelled parameters (e.g., Manning's n value) could be adjusted to better represent measured data, thereby reducing the time step of the model simulation. However, given that the loading time interval in the model is daily, this would provide minimal return with respect to the water quality simulation. Work is ongoing to optimize these parameters in the model. Future dye studies in the North Saskatchewan River should incorporate instantaneous (slug) as well as longer injection times (e.g., one day) corresponding to the model effluent loading time interval to improve calibration results.

3.3   Temperature Calibration

Water temperature strongly affects chemical and biological reaction rates, and is critical for reliable water quality simulations. Water temperature was evaluated to ensure correct representation of heat transport in the NSR mainstem. Observations from nine datasonde stations in the model domain were compared in the calibration (Table 3-1; Figure 3-1). The availability of measured data varies among sites. Where available, datasonde data were synthesized from a 15-minute data collection interval to produce hourly-averaged temperatures. Close correlations with calibration statistics are generally observed at most sites. On average, predicted water temperature is within 1°C of observed water temperature for all downstream stations with slight over-prediction (positive mean error) in downstream stations compared to upstream sites (Table 3-6). Overall absolute mean error of less than 1°C is within the range of error reported for other river applications of EFDC and similar models (TetraTech 2006b; Cole and Wells, 2008).

The placement of datasonde sites in the IH reach is constrained by field logistics; as such, these locations are typically near the river banks. The intent of datasonde deployments is to capture long-term and diurnal trends of in water quality parameters such as temperature and dissolved oxygen. The depths at which these instruments are installed vary from 0.6 to 1 m. Because of power generating operations at the dams on the NSR, instream flows may vary by over 50% within a day and water levels by 0.6 m. Such diurnal variation in flow produces variable depths at datasonde sites, which likely influence datasonde measurements to some degree.

Localized effects on depth are accounted for, in part, in the 2-D model domain, though representation of localized effects is limited by the model grid resolution (e.g., 5 equidistant cells across the channel). Grid adjustment to enable more accurate depiction of diurnal temperature changes observed in the datasonde data is ongoing. Specifically, the present version of the model grid has segment widths (J) equidistant for the 2-D portion of the grid (from Devon to Pakan). The near-bank cells (J4 and J8) require adjustment to better characterize local (near-bank) depths.

Although time series were produced at all nine stations, trends for two representative sites (Ft. Saskatchewan and Pakan) are shown graphically here (Figure 3-10 and 3-11). See Appendix C for comparison of modelled and measured time series for additional sites

through the model domain. Model predictions follow the observed data well; however, there are discrepancies between measured and modelled water temperature for the downstream stations, and these are primarily related to boundary conditions for heat transport (e.g., local changes in weather and depth). As noted above, finer-scale calibration is ongoing to better represent instream temperature variability. Contour plots of temperature (Figure 3-12) illustrate changes in temperatures along the IH reach of the model domain for a day in the timeframe of the model run.

Table 3-6. Error measures for datasonde vs. modelled data: hourly average temperature.

Location	Mean Error	Normalized Mean Error	Mean Absolute Error	Normalized Mean Absolute Error	Root Mean Square Error	Sample Size
Unit	($^\circ$C)	(%)	($^\circ$C)	(%)	($^\circ$C)	-
Devon	0.054	0.431	0.558	0.005	0.040	23176
US of Capital Region WWTP	-0.126	0.436	0.646	-0.016	0.055	8414
Ft. Saskatchewan	-0.069	0.477	0.705	-0.007	0.051	9633
Upstream of RR Trestle	-0.146	0.812	1.057	-0.009	0.052	316
Downstream of RR Trestle	-0.204	0.610	0.770	-0.013	0.039	314
Vinca	0.248	0.566	0.837	0.024	0.054	7967
Pakan	0.026	0.608	0.850	0.002	0.053	20482
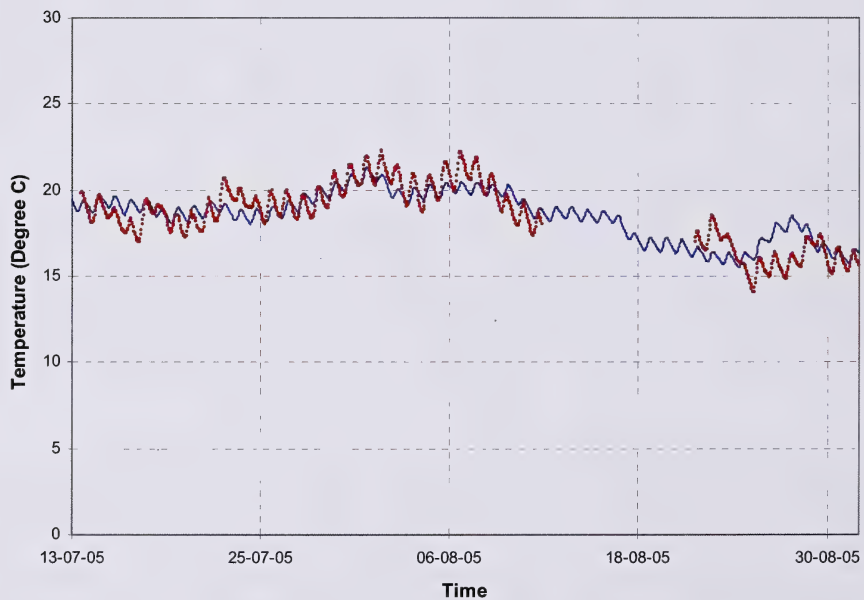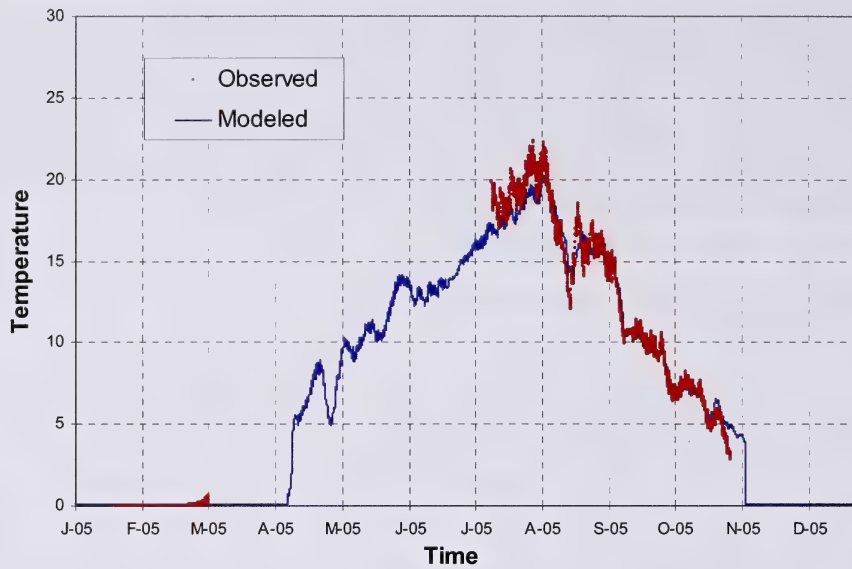
Figure 3-10. Instream modelled vs. observed temperature during 2005 at Fort Saskatchewan (measured data in red; modelled data in blue).
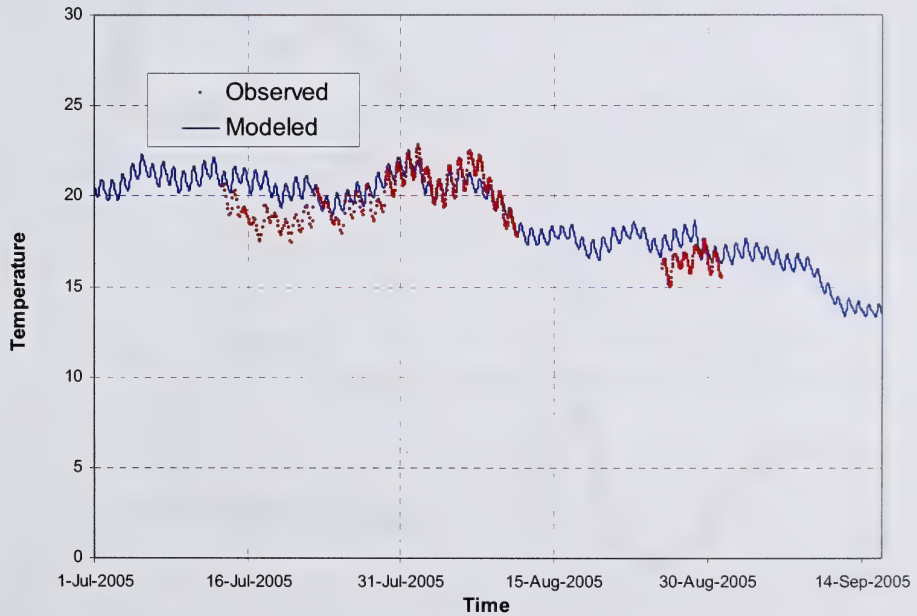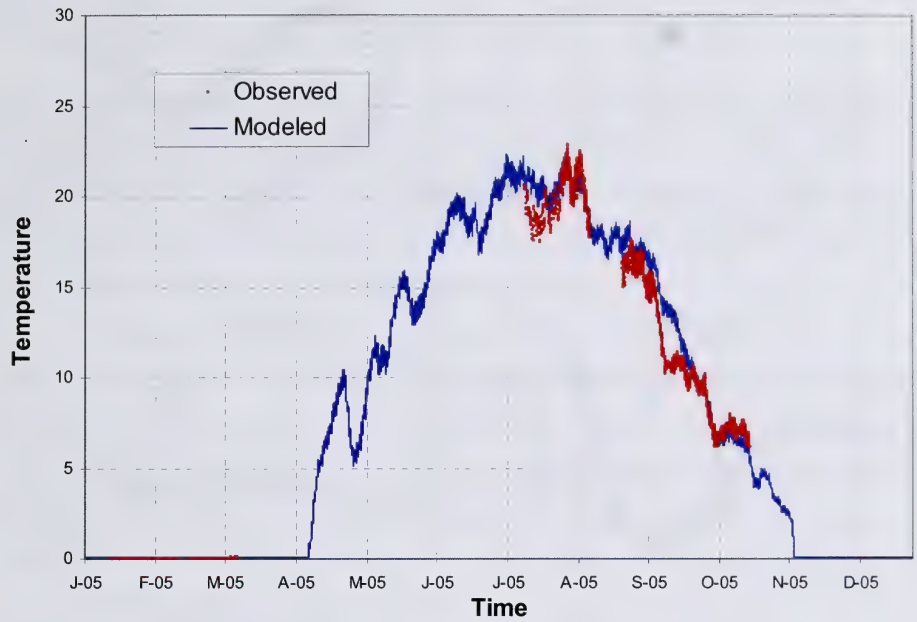
Figure 3-11. Instream modelled vs. observed temperature during 2005 at Pakan (measured data in red; modelled data in blue).
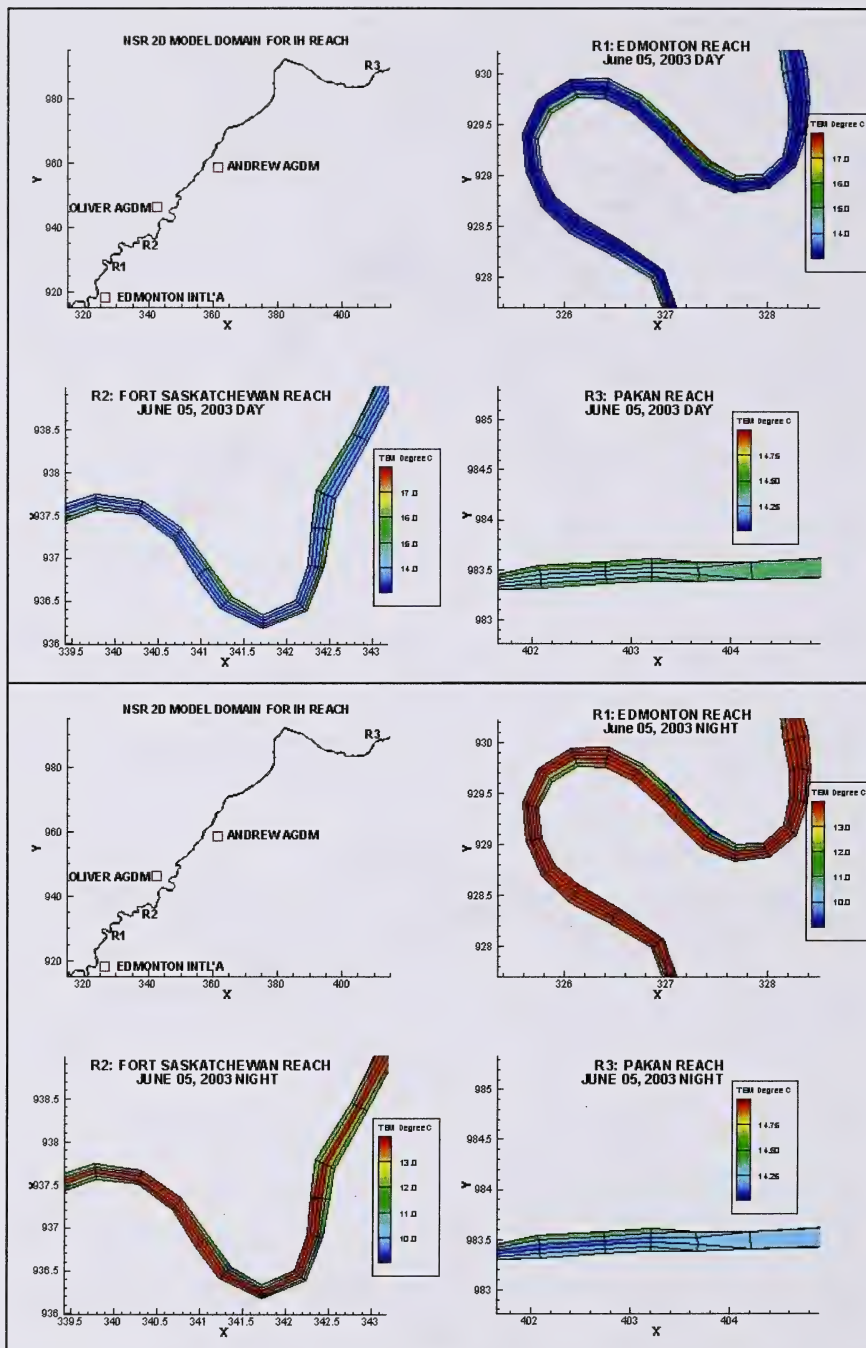
Figure 3-12. Contour plots of modelled temperature: night and daytime examples (note different scales).

3.4   Water Quality Calibration

3.4.1   Water Quality Components and Calibration Parameters

Water quality components were calibrated following the completion of hydrodynamics and heat transport calibrations. Water quality calibration involved examining the major reaction calibration parameters and adjusting these until model results reached acceptable agreement with the data. The present model simulation includes the variables listed in Section 2.3.2. The EFDC water quality model is capable of simulating phytoplankton, stationary algae (benthic), and macrophytes. Two groups are represented in the current model configuration: phytoplankton and benthic algae.

The major calibration parameters that were adjusted for this iteration of the model include the ammonia nitrification rate, organic carbon dissolution rates, organic phosphorus hydrolysis rates, and algal growth, death, and respiration rates. Other constituents yet to be calibrated include fecal coliform bacteria, metals, and (potentially) some organic compounds. Table 3-7 provides a summary of model output variables with corresponding monitoring constituents (see TetraTech, 2006a for detail on EFDC output variables). Table 3-8 shows kinetic coefficients and water quality calibration parameters employed in the present application.

Table 3-7. Mapping table: EFDC output variables vs. monitored water quality constituents.

EFDC output notation	Monitored water quality constituents
NHX	AMMONIA
DOC	DOC
ROC + LOC	POC
DOC + ROC + LOC	TOC
MAC x 16.7	chla_epi
CHC x 22.0	Chla
NOX	NO23
RON + LON	PN
RON + LON + DON + NHX + NOX	NOXTN
DOX	DO
P4D	PO4
ROP + LOP	PP
ROP + LOP + DOP	TP
P4D + DOP	TDP

Table 3-8. Major EFDC water quality calibration parameters.

EFDC Parameters	Calibrated Values
Minimum dissolution rate (1/day) of RPOC	0.002
Minimum dissolution rate (1/day) of LPOC	0.045
Minimum dissolution rate (1/day) of DOC	0.05
Maximum nitrification rate (gN/m3/day)	0.500
Nitrogen half-saturation for phytoplankton (mg/L)	0.030
Nitrogen half-saturation for benthic algae (mg/L)	0.03
Phosphorus half-saturation for phytoplankton (mg/L)	0.003
Phosphorus half-saturation for benthic algae (mg/L)	0.003
Optimal depth (m) for benthic algae growth	0.250
Maximum growth rate for phytoplankton (1/day)	1.50
Maximum growth rate for benthic algae (1/day)	1.50
Basal metabolism rate for phytoplankton (1/day)	0.04
Basal metabolism rate for benthic algae (1/day)	0.04
Predation rate on phytoplankton (1/day)	0.215
Predation rate on benthic algae (1/day)	0.215
Settling velocity for phytoplankton (m/day)	0.15
Coefficient for SOD at 20°C (g/m2/d)	0.7

mg/L = milligrams per liter

3.4.2   Estimation of Input Loads

Water quality data for ten stations were used for model calibration (Table 3-4). The model calibration was applied over the period from 2001 to 2008. This is the same timeframe for which water quality and quantity data were assembled and utilized in developing engineering options to facilitate outcomes consistent with the Industrial Heartland Water Management Framework (IHWMF). This is an optimal period for the NSR model calibration, as ambient sample collection and analyses were done in a reasonably consistent manner during that time. Moreover, the range of data variability is good during this time, as it represents a period where upgrades occurred in wastewater treatment plants that discharge to the North Saskatchewan River.

The EFDC model incorporates a dynamic sediment process model; however, sedimentation and resuspension were not activated in the present model application (due in part to limited field data). Presently, a constant value is specified for benthic fluxes (Table 3-8).

Data from various sources were used to estimate loads from point source facilities and tributaries. The sources from which loads were derived include:

- Responses from questionnaires sent out as a part of the Industrial Heartland Water Management Framework Scoping Study (Project 1) to all dischargers.
- Data retrieved from the Department's Environmental Management System (EMS) and Water Data System (WDS).

- Data provided by the City of Edmonton Drainage Services for loadings from CSOs, storm sewers and Gold Bar Wastewater Treatment Plant (WWTP), and; Capital Region & Devon WWTPs for the loadings from these facilities.
- Effluent surveys conducted by Alberta Environment staff in the summer of 2007 and winter of 2008.
- Synoptic studies conducted by Alberta Environment staff in 2008 to support cumulative effects assessment and modelling in the NSR basin. Effluent grab samples were collected from major discharge facilities, on a sample schedule designed to approximate river travel time.

The majority of the point source loads used as inputs to the model were derived from data in WDS and EMS, which include daily effluent BOD_5, discharge rate and some nutrient data for industrial facilities and municipal WWTPs. The information in WDS and EMS is largely supplied by approval holders (dischargers) as per requirements of their approval. The loading values applied as model input follow the assumptions given in Section 2.3.3.3. Information not submitted by the dischargers as a part of their approvals (e.g., particulate / dissolved fractions) was derived and applied as model input based on effluent information that was gathered by AENV from the effluent surveys and synoptic studies noted above.

Monitoring data were compiled and formatted to facilitate conversion to EFDC state variables. Concentration values from all tributaries over the entire sampling period were used; daily loading data for individual tributaries were derived from interpolation of discreet concentration measurements applied to daily flow data. Values for tributaries without measured data were estimated by averaging values for tributaries for which measured data exists (including the tributaries above the upstream boundary location). This results in some uncertainty in load estimations that will limit the applicability of the present model results for water quality. A comprehensive data set including detailed data for all tributary and non-point source loads is essential for a reliable water quality modelling. A watershed modelling approach may be necessary to reasonably estimate the tributary and nonpoint source loads. Key water quality parameters include ammonia, DOC, TOC, nitrate, TKN, dissolved oxygen, total phosphorus, and dissolved phosphorus.

As this document is focused on model calibration, detailed analysis of relative loadings from individual point sources and facilities is not given here. Appendix D provides a summary of existing loads (by discharger and by sector) employed in the present model application. This provides loading estimates on inter-annual and seasonal timescales to illustrate the variability involved for two parameters. Note that actual loads vary considerably through time, and treatment processes for some point sources have been significantly upgraded in recent years. Where available, time-varying data for point sources provided input for the model. A more detailed evaluation of contaminant loads in the NSR is underway and will be documented in upcoming reports.

Overall, the loading data suggest that:
- Point source nutrient loading to the NSR downstream of Devon is predominantly from the wastewater treatment plants, which account for 70% to 80% of the point-

source nitrogen load (TKN, nitrite and nitrate, and ammonia) and 60% to 70% of the point-source phosphorus (TP and TDP)load. However, NSR loads at Devon are quite variable, and can account, for example, for up to 90% of the phosphorus load delivered to the IH reach in spring, and less than 25% of the load during late summer conditions.

- CSOs and storm sewers generally contributed less than 10% of the total organic and nutrient load into the NSR over the 2000 to 2007 period. However, it is important to note that this is highly variable seasonally and with episodic events.
- Significant organic carbon loads in the NSR are produced by tributaries, which contribute about half of the TOC and DOC loads.
- The predominant loading from WTPs is in the form of particulate organic carbon (perhaps related to activated carbon).

3.4.3   *Dissolved Oxygen Calibration*

Predicted dissolved oxygen concentrations were compared to observed data for nine datasonde stations (Table 3-1, Figure 3-1). Continuous monitoring data were synthesized (from 15-minute intervals) to provide hourly (average) dissolved oxygen data for calculation of error measures.

Time series comparisons of observed vs. modelled dissolved oxygen (DO) values show reasonable model performance for dissolved oxygen, in that the model tracks seasonal variability in dissolved oxygen; e.g., low summer DO concentrations and higher winter concentrations (Figure 3-13 to 3-15). Diurnal DO variability is represented well by the model for most of the downstream stations (Pakan and Vinca). Contour plots of dissolved oxygen (Figure 3-16) illustrate diurnal changes in dissolved oxygen along the IH reach of the model domain for a day during the time frame of the model run.

In colder ice-covered conditions, modelled DO shows relative diurnal stability due to low algae metabolism at low water temperatures, limited reaeration, and lower bacterial activity, which influences organic matter decay and nitrification. The observed data show some slight fluctuations under-ice DO. This may be due to limited algal growth dynamics and water temperature changes within a small range. In warm weather, algal growth accelerates and water column DO responds strongly. The model generally reproduced such patterns for most of the NSR stations. Additional data for modelled vs. measured DO are illustrated in Appendix E.

The figures show that the model is able to capture major trends, including DO swings due (in part) to algal abundance. In addition, statistical measures of model accuracy demonstrate the model's ability to simulate temporal and spatial differences in DO concentration (Table 3-9). The mean error for dissolved oxygen concentration (predicted – observed) in the reach upstream of Fort Saskatchewan was less than 0.3 mg/L, which represents a normalized mean error of less than 0.03%. In general, this is acceptable overall performance for a river DO model (TetraTech, 2006b). Error measures upstream and downstream of RR Trestle and Lea Park indicate some over-prediction in DO. For the Vinca and Pakan sites, modelled DO concentrations are generally within 1 mg/L of

the monitored data, with modelled values higher than the observed. A better apparent statistical fit (i.e., better model accuracy) at these stations reinforces the presence of localized processes that influence DO.
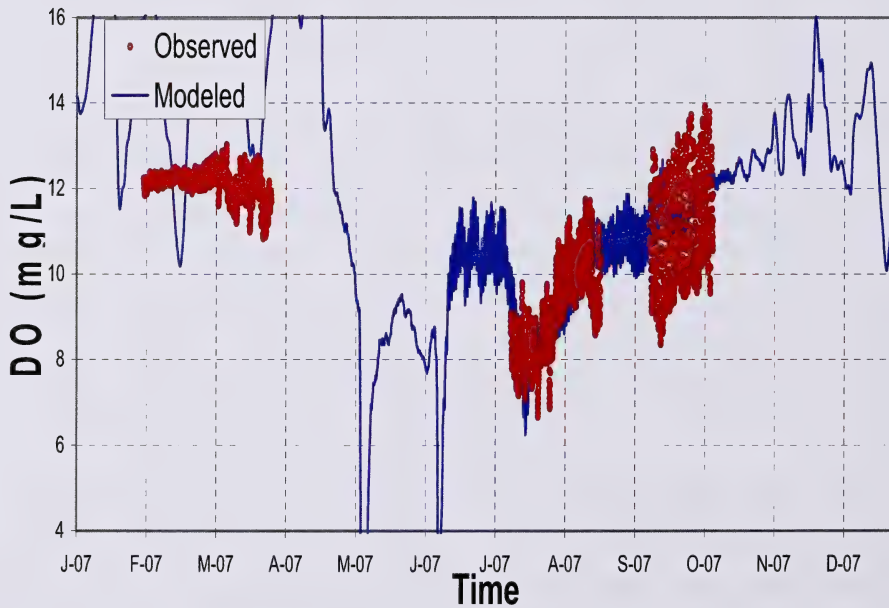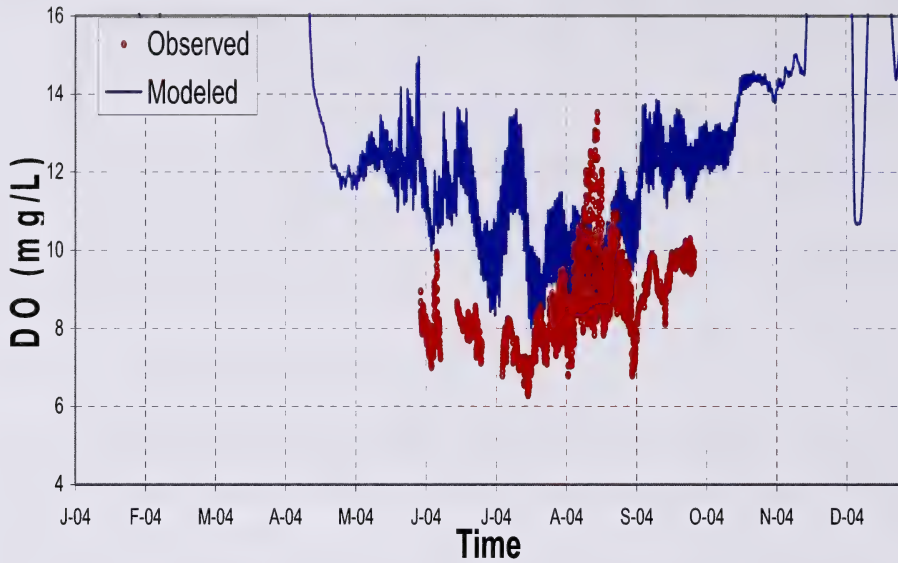
Figure 3-13. Modelled and observed dissolved oxygen concentrations during 2004 and 2007 at Vinca.
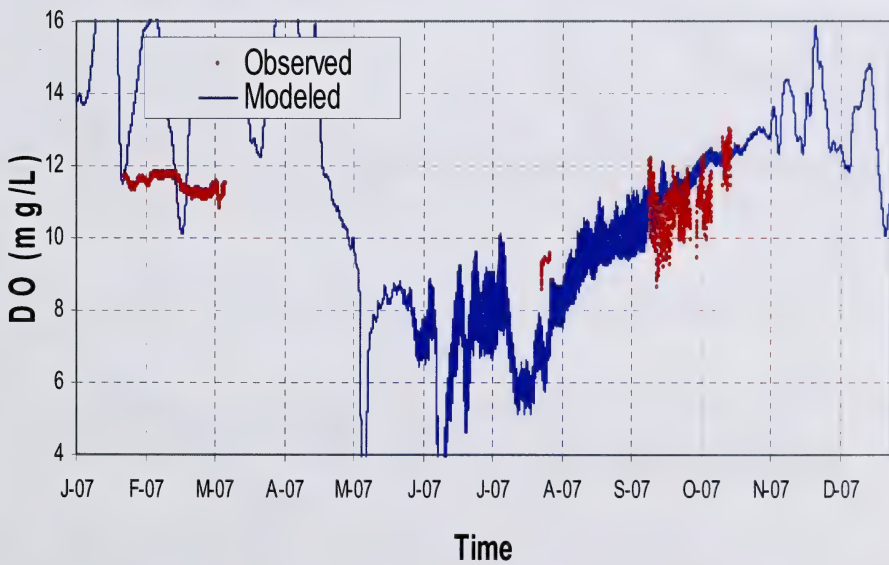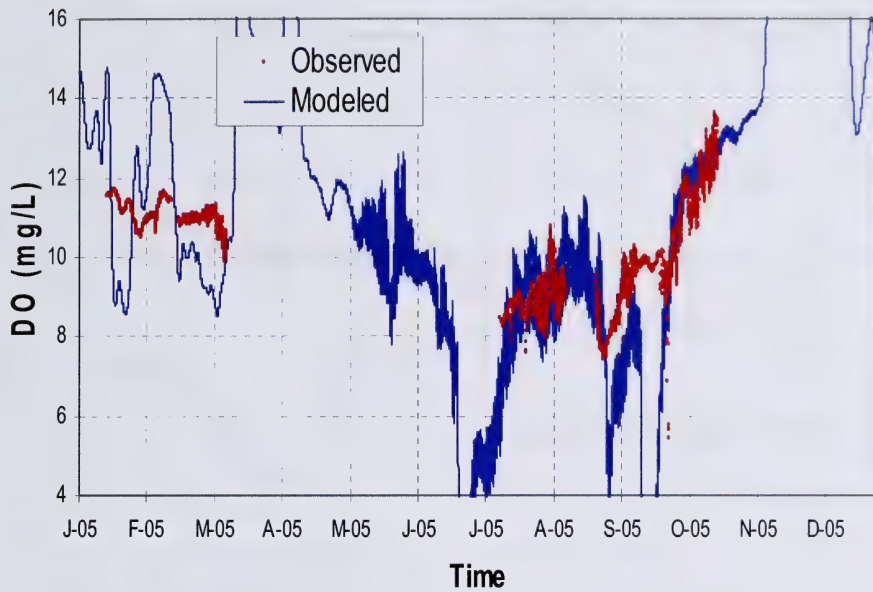
Figure 3-14. Model predicted and observed dissolved oxygen concentrations during 2005 and 2007 at Pakan.
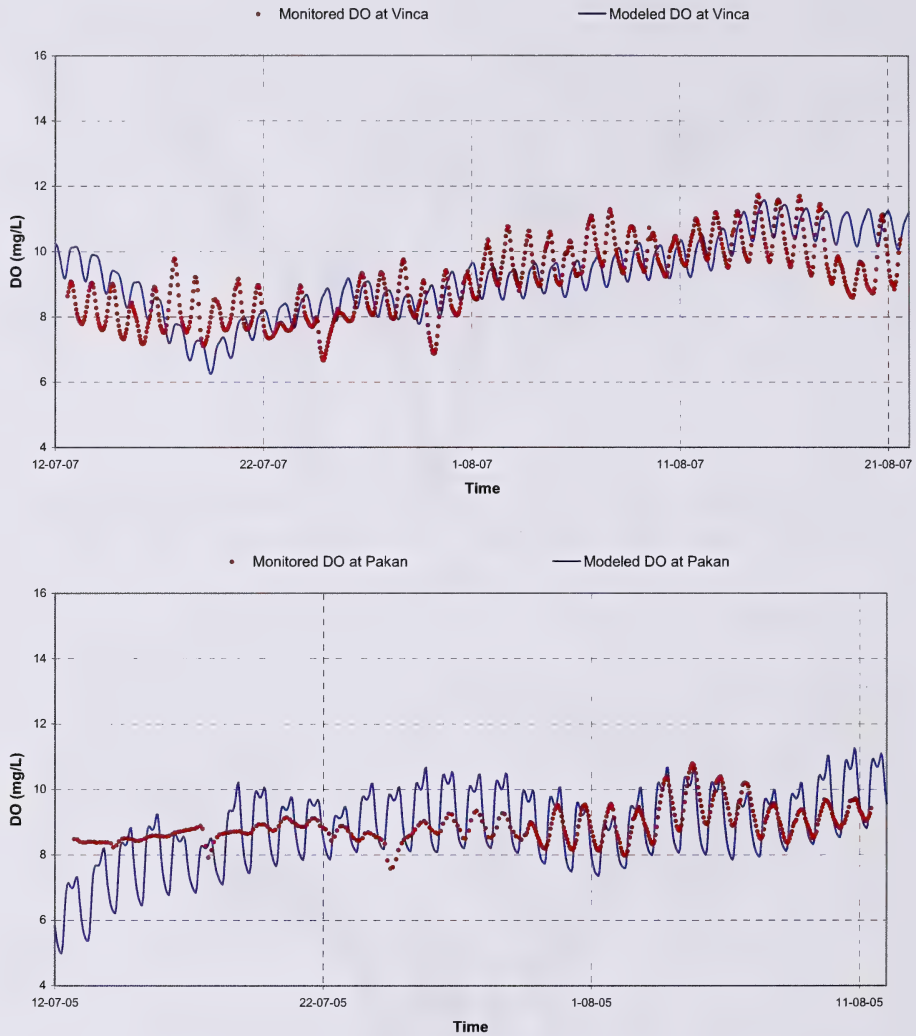
Figure 3-15. Example plots of predicted and observed dissolved oxygen
concentrations at Vinca and Pakan, illustrating diurnal variability.
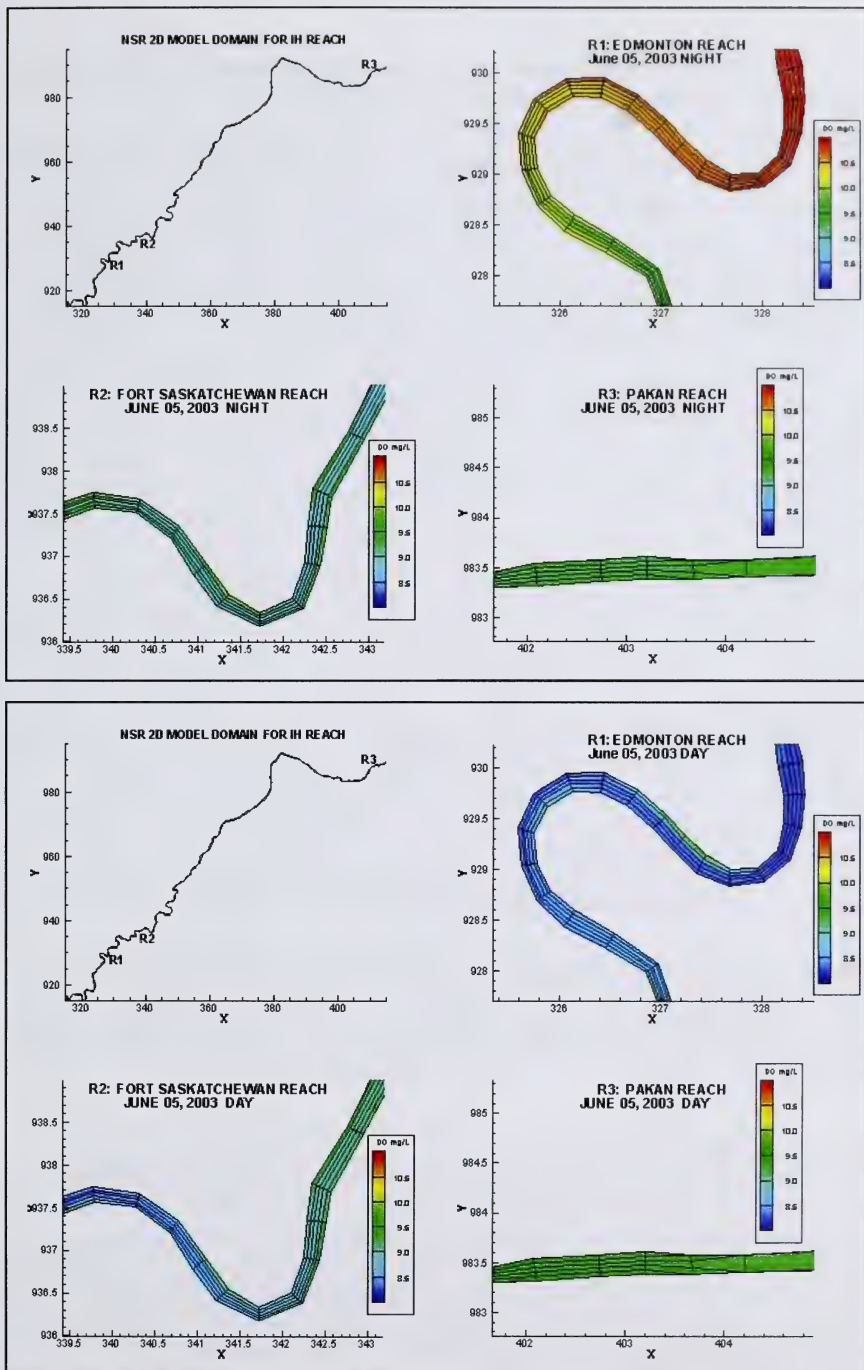
Figure 3-16. Contour plots of dissolved oxygen: night and daytime examples.

Table 3-9. Preliminary error measures for datasonde vs. modelled data: hourly average dissolved oxygen.

Location	Mean Error	Normalized Mean Error	Mean Absolute Error	Normalized Mean Absolute Error	Root Mean Square Error	Sample Size
Unit	(mg/L)	(%)	(mg/L)	(%)	(mg/L)	-
Devon	0.271	0.027	0.481	0.048	0.651	20024
US of Capital Region WWTP	0.131	0.012	0.929	0.083	1.256	8068
Ft. Saskatchewan	0.336	0.031	0.9	0.083	1.204	9331
Upstream of RR Trestle	1.840	0.191	2.463	0.256	2.725	316
Downstream of RR Trestle	1.861	0.193	2.481	0.258	2.750	316
Vinca	1.050	0.105	1.448	0.144	1.984	8715
Pakan	0.889	0.090	1.193	0.120	1.498	17058
Lea Park	2.395	0.270	2.395	0.270	2.513	2996

3.4.4   Model Divergence: Influences on DO and Nutrient Calibrations

Modelled DO (and other) data at Devon reflect model boundary conditions, as the location is very close to the upstream boundary. At downstream sites, the model does reproduce realistic dissolved oxygen values over a broad time spectrum. Finer-scale fluctuations (e.g., diurnal) are not as consistently well-resolved. A number of key factors influence this:

Local flow and depth variability
As discussed in Section 3.3, the model representation of datasonde data should improve as near-bank cells (J4 and J8) are adjusted to better characterize local (near-bank) depths. Datasonde deployments in the NSR are typically near the river banks at water depths of about 1 m or less. Dam operations on the NSR can cause water levels to vary over a day by 0.6 m. This results in variable depths at datasonde sites, which can influence instrument measurements. Localized effects on depth are partly accounted for in the existing 2-D model domain, though this is limited by grid resolution (e.g., 5 equidistant cells across the channel). Grid adjustment to enable more accurate depiction of diurnal changes is ongoing. Specifically, the near-bank cells (J4 and J8) require adjustment to better characterize local (near-bank) depths.

Algal dynamics and biomass
Variability of biomass in time and space is a key driver of DO changes. In particular, benthic algae and macrophytes can play a significant role diurnal DO fluctuations. Some key factors that influence modelled algal abundance are briefly discussed here.

Velocity effects on benthic algal growth
Monitoring of the NSR suggests that epilithic growth is concentrated near the banks and most benthic sampling work is conducted near-bank. In our initial model calibration, epilithic growth was not limited by velocity; i.e., growth was represented as constant across the channel at any given time. Monitoring in Alberta and elsewhere indicates that benthic growth is limited by river velocity (e.g., Robinson et al., 2009; Francoeur and Biggs, 2006). Accordingly, we utilized a velocity-limiting component to epilithic growth in the model. This is a logistic function, described in EFDC documentation (5 parameter - TetraTech, 2006a). In addition, we utilized hourly flow data for boundary conditions, which allowed better representation of local velocity variations (e.g., lower velocity in near-bank cells relative to the center channel).

The model uses average depth for each grid cell and thus generally cannot fully capture variable concentrations of benthic algae without significant additional discretization. However, model results do show higher benthic algal abundance in areas of lower velocity. Higher modelled daytime DO levels in some near-shore areas may reflect this growth pattern. To illustrate, dissolved oxygen levels vary with temperature and primary production. The solubility of DO in water decreases with increasing temperature, as represented by a general increase in night-time DO levels, relative to daytime. However, prediction based solely on solubility is complicated by algae, which photosynthesize during the day (producing oxygen) and respire at night (using oxygen). Hence, modelled daytime DO levels, elevated in some near-bank areas relative to the center channel, indicate algal growth in these areas (e.g., Figures 3-12 and 3-16).

Seasonal algal growth
Experience with other rivers suggests that biomass accumulates in summer with probable peaks in late summer to fall (September to November). In addition, benthic growth is generally enhanced downstream of nutrient inputs. This pattern is reflected the NSR (Figures 3-12 to 3-14), wherein diurnal variability is:
- typically low at Devon;
- generally low in spring at all locations;
- and greater downstream of nutrient inputs; and
- greater in the fall.

Algal groups are sensitive to water depth (see discussion of local depth above) and vary significantly with location and substrate type. This variability is illustrated in Figure 3-17, which provides a simple summary of observed benthic algal abundance in the NSR. Figure 3-18 shows average dominance of diatoms relative to other groups in the NSR at Devon and Pakan (AENV, unpublished data). As an average of multi-year data, note that this figure does not show succession in algal communities, which is also significant

seasonally and with river location. Each taxon has particular metabolic characteristics, which influence uptake and loss of nutrients and DO.

To better reproduce algal and plant growth in the model, kinetic parameters associated with algal dynamics require further fine-tuning. These include coefficients that define temperature, light, and nutrient limitation, which are dependent on the nature of ambient algal communities. In addition, representation of seasonal succession of algal communities has not been addressed. Further work is ongoing to address these caveats, in order to provide more accurate estimates of algal dynamics through the model domain. This will include some representation of macrophytes, which can significantly influence diurnal DO swings in Alberta rivers (e.g., Robinson et al., 2009).
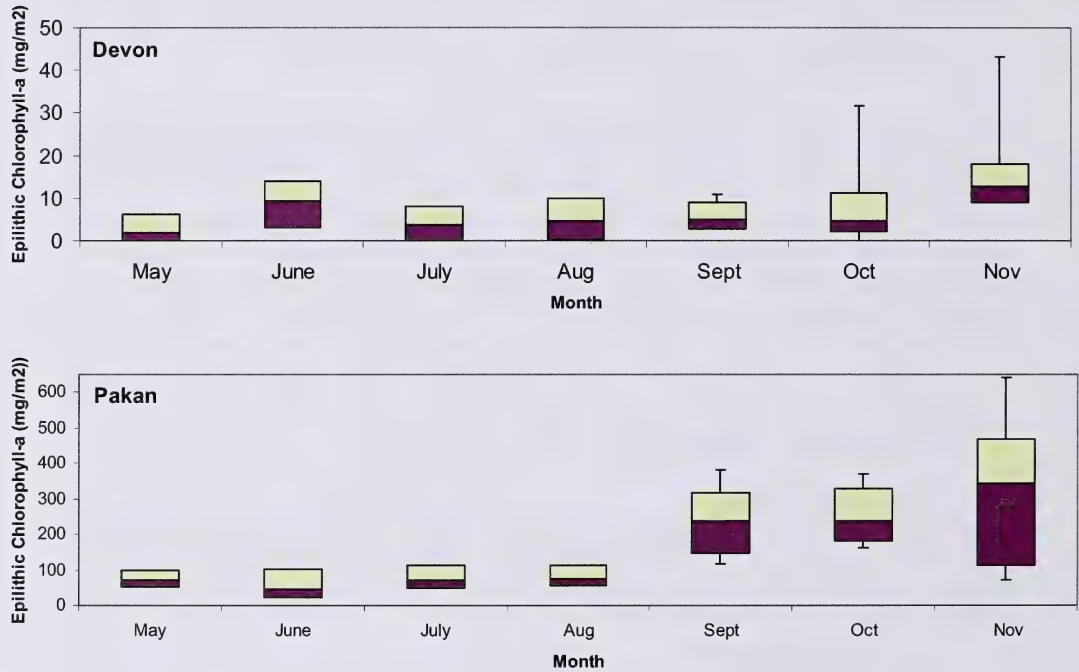
Figure 3-17. Box and whisker plots of epilithic chlorophyll-*a* in the North Saskatchewan River at Devon and Pakan, 2000 – 2008 (note difference in scales).
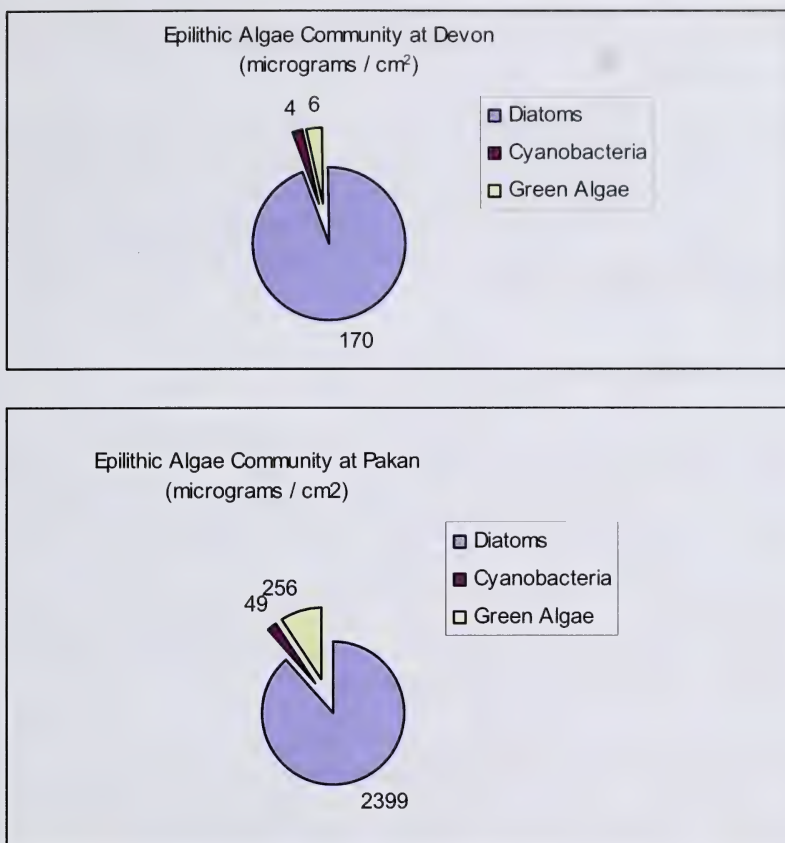
Figure 3-18. Epilithic algal community in the North Saskatchewan River at Devon and Pakan, mean 2000 – 2008 (note increase in overall abundance between Devon and Pakan).

Sediment Oxygen Demand

Streambed or sediment oxygen demand (SOD) results in the removal of dissolved oxygen from the water column. For the present calibration, one SOD rate was used for the modelling domain (spatially variable SOD was not assigned). Measured SOD values can be quite variable, spatially and temporally; as a result, DO is over-predicted by the model in summer and under-predicted in winter at some locations. Figures 3-12 to 3-14 suggest that a greater SOD sink exists in the NSR during summer; this is partially captured by temperature dependence as implemented for SOD in the model.

SOD data were derived using the following equation:

$$SOD(t) = SOD(20)\ \theta^{T-20}$$

where SOD(20) is the sediment oxygen demand at 20°C, and θ is an empirical temperature multiplier. An SOD (20) value of 0.7 g/m2/d with a multiplier of 1.4 is used in the current simulation.

Given the potential variability in SOD through the NSR, future model development will include the capacity for user-defined areal SOD variability. Though minimal measured SOD data exists for the NSR, SOD measurements from other rivers supports estimation of initial SOD values for NSR locations (e.g., Casey and Noton, 1989; Yu, 2006 and references therein, etc.). Additional calibration factors influencing modelled DO concentrations are discussed in Section 4.

3.4.5   Nutrients, Chlorophyll α, and Carbon

Modelled parameters include dissolved and particulate organic carbon (DOC and POC), total organic carbon (TOC), ammonia nitrogen (NH4), nitrate + nitrite nitrogen (NO23), particulate and total nitrogen (PN and TN), dissolved phosphate (PO4), dissolved and particulate fractions of phosphorous (TDP and TP), chlorophyll-*a* (Chl *a*) and benthic algae (Chl *a*_epi). Figures 3-19 to 3-21 compare model output with measured data for two key water quality sites in the IH reach (Devon and Pakan) and an additional site at the downstream end of the model (Highway 17). Appendix F provides comparative graphs and tables of broad error measures for each of nine sampled sites on the NSR from Devon downstream to the Saskatchewan Border (Hwy 17).

Overall, the modelled water quality values agree with the observed data, relative to error measures reported for other river applications (e.g., TetraTech, 2006d). Seasonal variation of nutrients is captured, and modelled water quality constituents are within reasonable ranges. Because of uncertainties and limitations discussed above, an exact match between model results and observed data is not expected. Model calibration for nutrients is evolving as ongoing model development and calibration produces better representations of algal dynamics, nutrient cycles, and physical parameters that influence mixing and flow (Section 4). Figures 3-22 and 3-23 show example plots of model output, (cross-channel average) to illustrate longitudinal trends in nutrient concentrations.
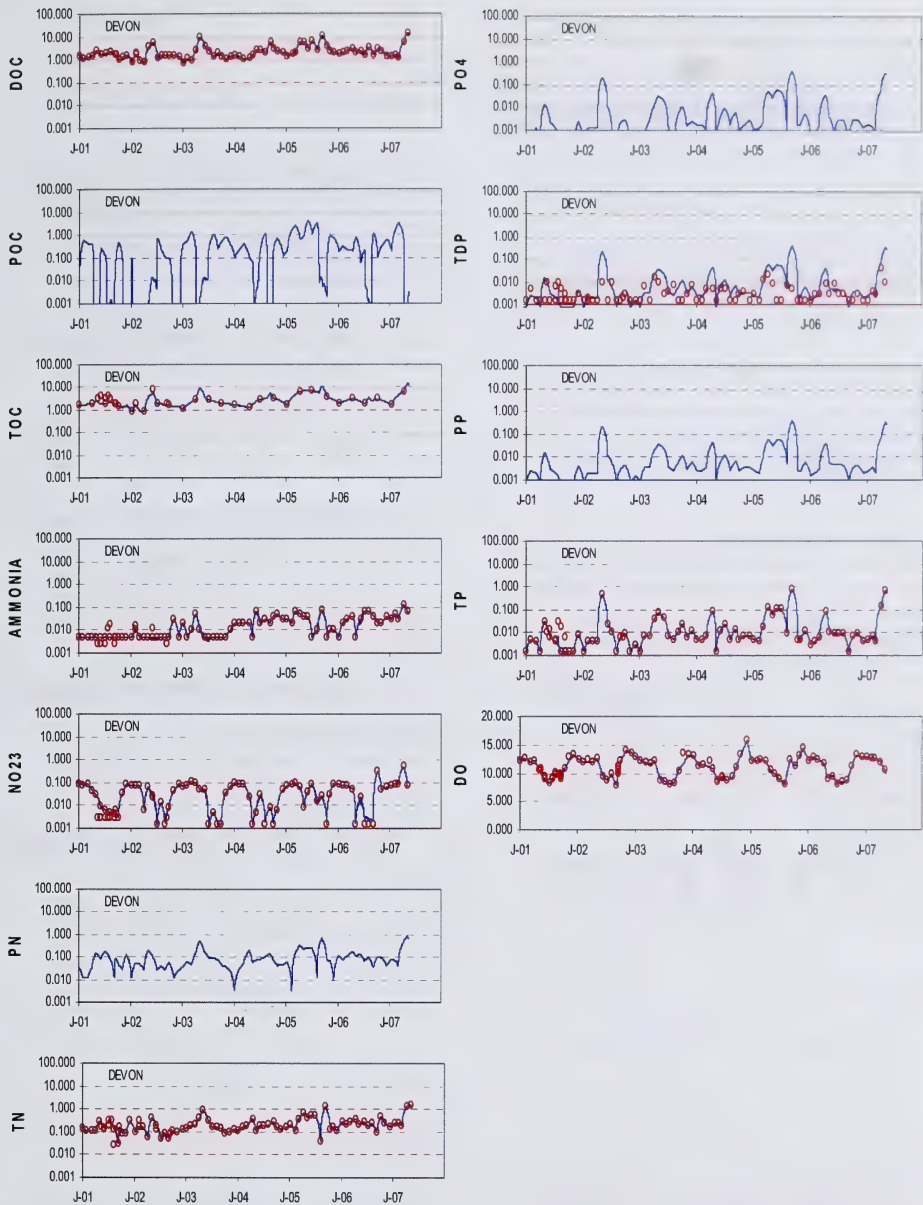
Figure 3-19. Modelled results (solid line) compared with field data (dots) for the NSR at Devon.
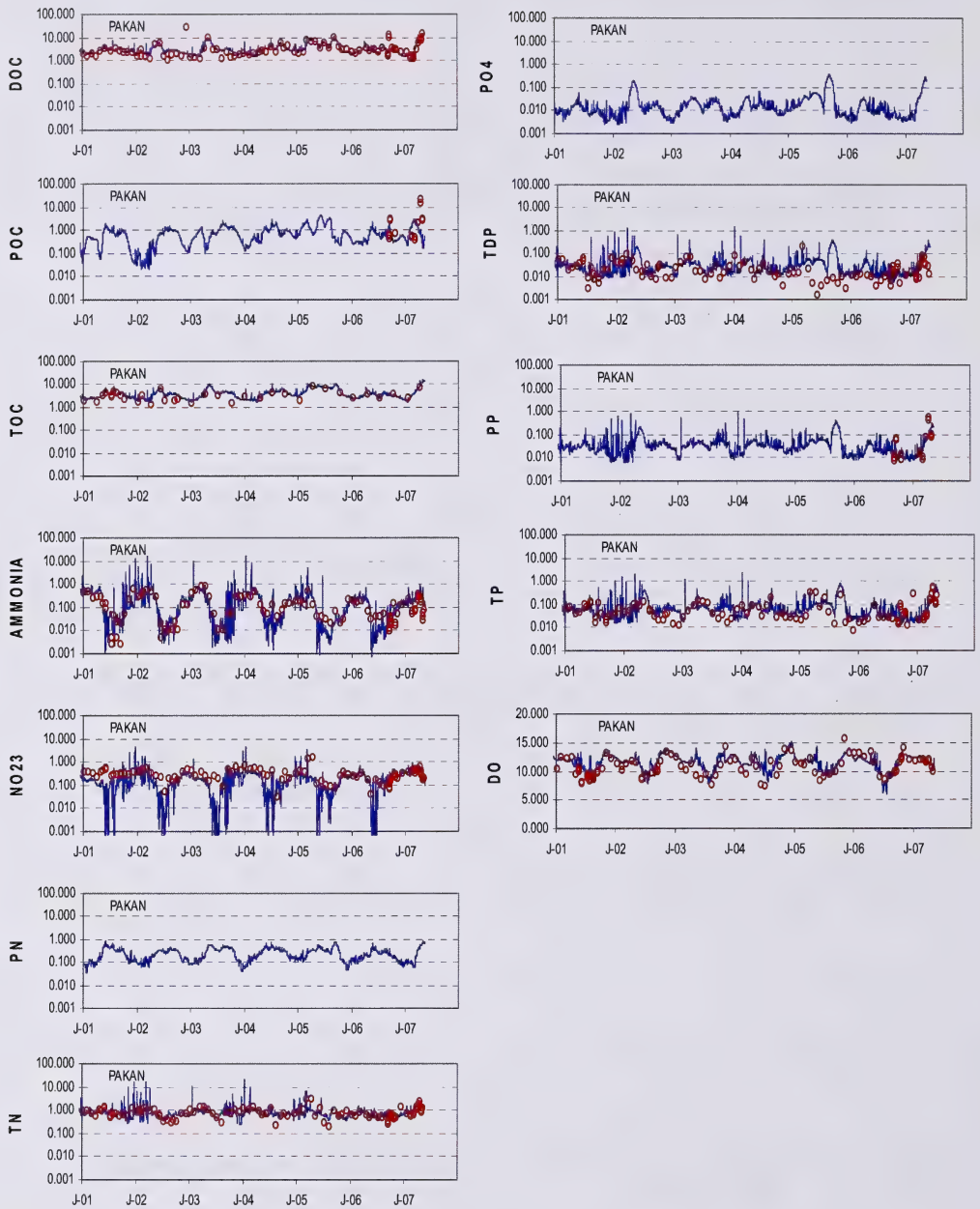
Figure 3-20. Modelled results (solid line) compared with field data (dots) for the NSR at Pakan.
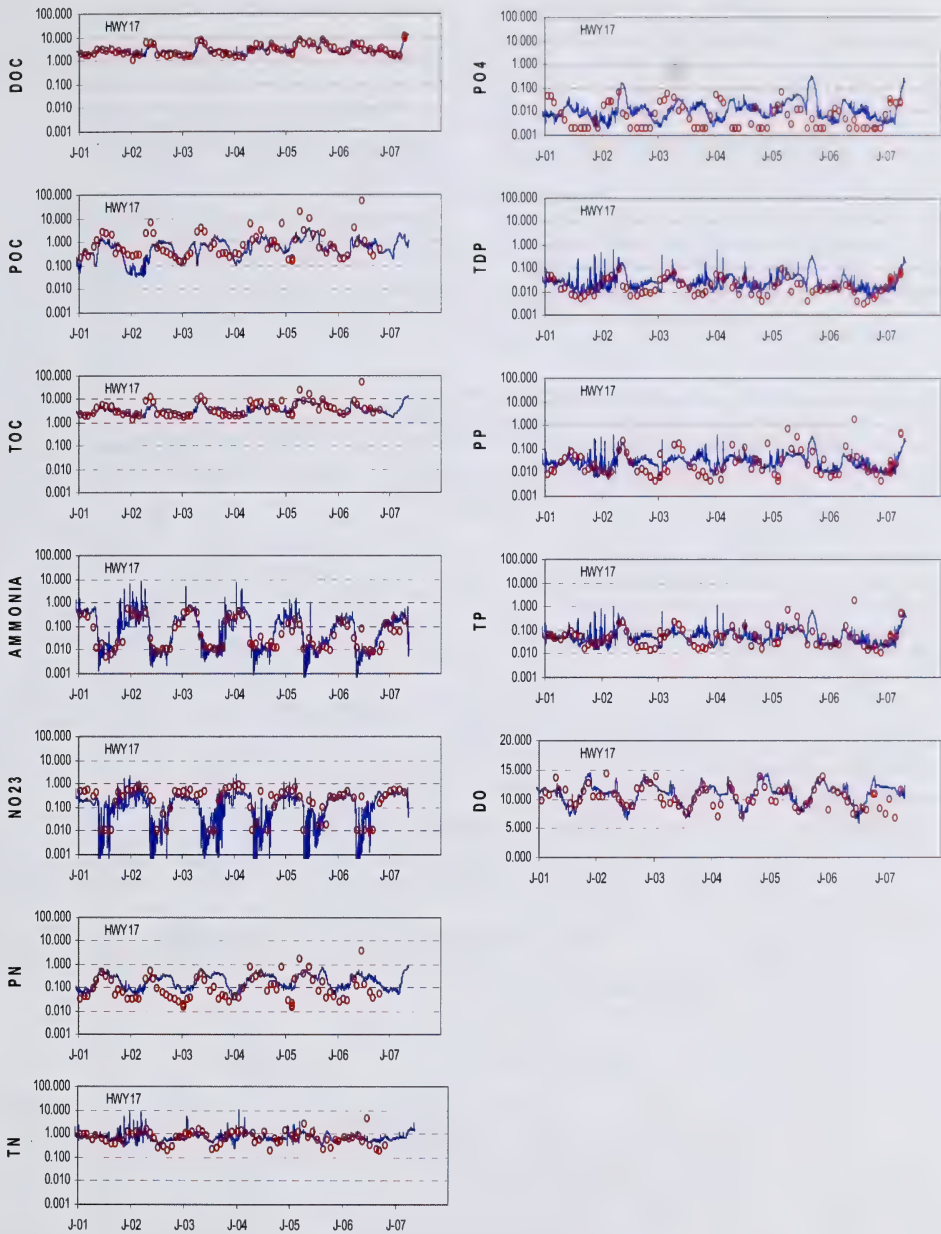
Figure 3-21. Modelled results (solid line) compared with field data (dots) for the NSR at Highway 17.
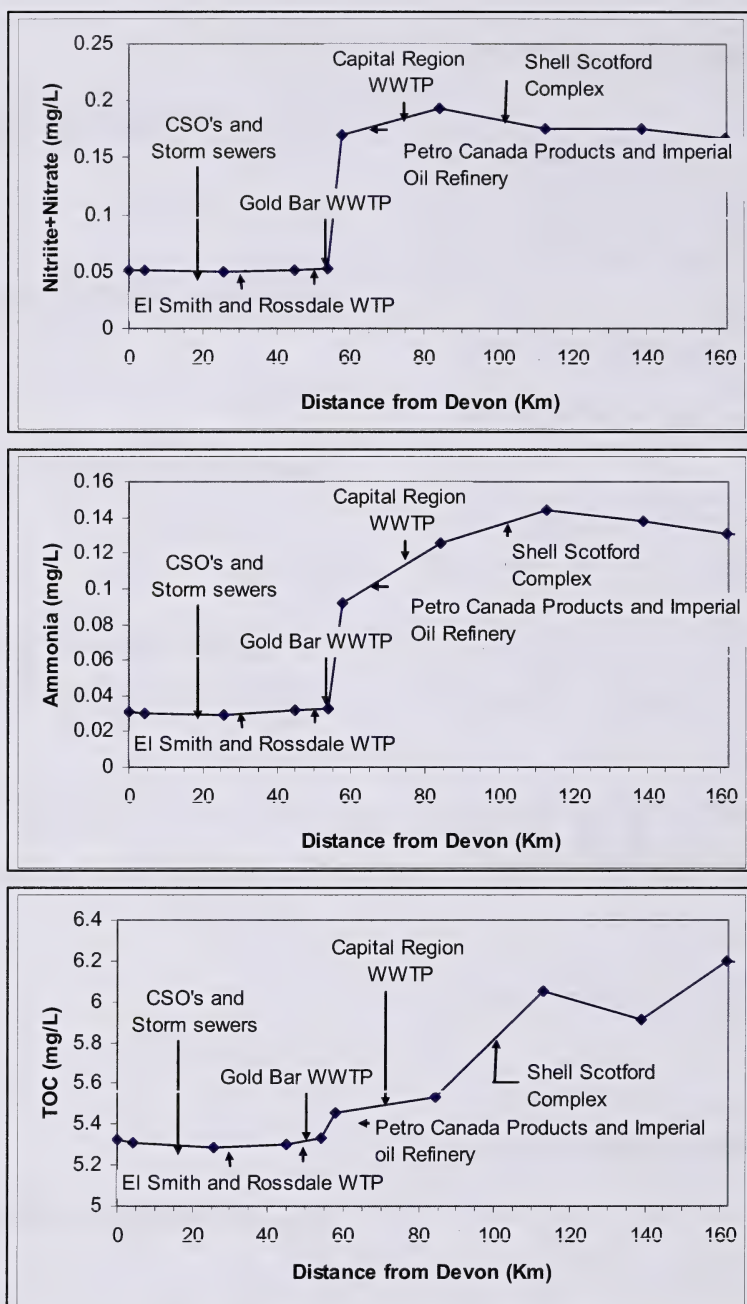
Figure 3-22. Average annual total organic carbon, ammonia, and NO2-NO3 concentrations in the NSR vs. distance downstream – 2005.
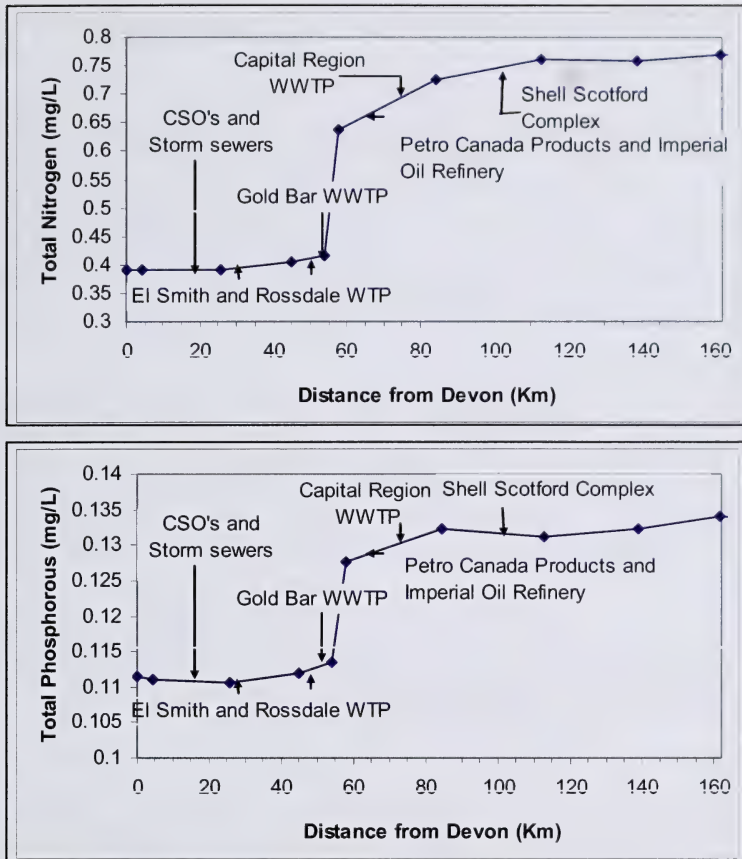
Figure 3-23. Average annual total nitrogen, and phosphorus concentrations in the NSR vs. distance downstream – 2005.

4.0 INFORMATION GAPS AND FURTHER MODEL DEVELOPMENT

Although model and observed data generally agree well, model results can be improved through further fine-tuning of the model. This is an ongoing and iterative process. Following is a summary of known issues that influence the predictive capacity of the NSR EFDC model. Work on some of these is underway, whereas others will be addressed as resources permit. Table 4-1 provides a summary of the issues identified here, along with their assigned priority and status. Updates to this document will be produced as model development and calibration proceed.

Tributary and watershed information
For the NSR, loadings from the tributaries play an important role in providing nutrients and organic carbon. Loading estimates are limited by available data. As a result, model loadings from the major tributaries are based on multiyear or monthly average values. A watershed model such as SWAT could be applied to the NSR basin to provide more accurate loadings and to support better flow balance results for the river. Existing run-off and transport coefficients could be incorporated to provide estimations of relative inputs to the NSR from tributary catchments. At this writing, SWAT modelling is underway for some NSR tributary basins (collaborative AENV-NSWA initiative), and this work will provide additional information to EFDC model flow and water quality predictions. However, <u>monitoring</u> data from these smaller streams and watersheds is ultimately needed to reliably calibrate a watershed model for the NSR – IH area.

Algal Dynamics
<u>Algal Groups</u>
One phytoplankton group and one benthic algal group are presently used in the model to represent overall primary production and nutrient interactions in the river. Additional groups (including macrophytes) may be needed to better represent seasonal succession, etc. (Section 3.4).
<u>Kinetic Coefficients</u>
Further tuning of various kinetic constants associated with algal dynamics is underway in an effort to improve model nutrient and biomass estimations. Factors include:
-   nutrient, temperature, and light limitations;
-   metabolic rates (growth, uptake, decay); and
-   winter (under ice) dynamics.
<u>Areal Limitations</u>
Benthic algae are sensitive to water depth and can be quite variable in abundance, depending on location, flow, turbidity, etc. The model uses average depth for each grid cell; consequently, additional discretization or grid modification is required to represent ambient conditions in the model domain at higher resolution, as needed.

Sediment Oxygen Demand
SOD is currently assigned as a constant value through the model domain, though a first order equation is implemented in the model for temperature dependence. Measured SOD values can be quite variable, spatially and temporally; as a result, modelled dissolved

oxygen is over-predicted in summer and under-predicted in winter at some locations. User-variable SOD values (by cell or reach) may improve the DO calibration. Implementation of this for the NSR model is underway. As noted above, little measured SOD data for the NSR exists, though SOD measurements done on other rivers will support estimation of initial SOD values for NSR locations.

Sediment Transport and Processes

EFDC is capable of simulating cohesive and non-cohesive sediment transport (including re-suspension), as well as the transport and fate of toxic contaminants in water and sediment phases. Cohesive sediment refers to silt and clay particles, while non-cohesive refers to anything larger than silt (e.g., sand, gravel). The dynamic sediment model was not activated for the current application, due in part to limited field data. Some monitoring is presently underway to address this information gap. A constant value is specified for benthic fluxes. As noted above, spatially variable SOD rates are being assigned to the model domain to partially rectify this issue. Existing field data on sediments can be used to some degree for calibration; this will be employed in our future NSR model development. However, more detail on sediments (e.g., chemistry, size fractions) is ultimately needed to constrain areal distribution of transport, resuspension and deposition.

Cross-Channel Distribution

Field data from NSR monitoring, as well as the NSR EFDC model runs in the IH to date, suggest that full mixing of the various point-source loadings to the NSR occurs by Pakan. However, it is not yet clear whether this occurs consistently, especially when flow rates are very low. Statistical comparisons are underway to resolve differences between cross-channel averages and individual cells. This will aid in determining the general extent of horizontal mixing of constituents such as total phosphorus and ammonia across the river. Finer resolution with respect to mixing at critical flows can be achieved through application of a near-field model (see below).

Near-field modelling

The NSR EFDC model can generally represent cross-channel mixing processes (5 active cells across the channel), though the longitudinal resolution is fairly coarse, at about 500 to 1,000 m. This provides sufficient resolution for representing river processes by reach. However, a near-field mixing model such as CORMIX may need to be applied to supplement the EFDC simulation in areas where clear identification of plume characteristics is an issue. For example, a near-field model would address the implications of one versus a number of outfalls represented in circumstances to be addressed in evaluating future loading scenarios for the Industrial Heartland. Verification of near-field modelling may require dye/tracer studies to be conducted.

Ice modelling

In developing the NSR model, EFDC model code was modified to account for the effects of ice cover on flow resistance, heat transport, and water quality simulation using externally supplied ice cover information. Ice cover data is user-specified; hence the

model is limited in its capacity to fully simulate fractional ice cover and related effects. Further development of the ice model component is needed to:
- represent the displacement effect of ice on water levels;
- evaluate chemical effects due to ice formation and decay;
- characterize variability in under-ice flow resistance; and
- represent fractional ice cover as a modelled function.

Short-term needs for ice modelling include thermodynamic effects of ice cover (e.g., realistic transfer of radiation (heat and light) through ice), as well as variable under-ice frictional effects.

Diurnal variability in flow and water quality
Power operations at the dams on the NSR produce significant variability in river flows over a day. This diurnal variation suggests that there is a daily variation in the concentrations of constituents such as total phosphorus and ammonia at Pakan. For example, if a measurement at Pakan is taken during a low-flow period, and all loadings have remained constant, the observed values will be much greater than the predicted values, which are based on a mean daily flow rate. Diurnal variation in sampled water quality is not captured in AENV data, and would need to be addressed through an enhanced monitoring study to support finer-scale (e.g., diurnal) model calibration.

Nutrient dynamics and loading estimates
Loading estimates are limited in their representativeness, because data quality (both in terms of analytical suite and methodology) is highly variable among discharges. This impedes the assembly and use of point-source information for modelling evaluations. Significant resources have been applied to assemble a searchable database of NSR effluent discharge data, a key requirement to support this modelling effort. All available information has been utilized from internal (AENV) sources, and from industry and municipalities directly. In general, many assumptions have been made to utilize effluent information in producing time series data for point source loading estimates. To illustrate, approval reporting requirements are often limited with respect to parameter suites and sample frequency. More coordinated and consistent <u>monitoring</u> of point source effluents would produce more robust loading estimates (e.g., for key nutrient parameters), which in turn would facilitate better more reliable modelling of instream nutrient dynamics.

Additional Parameters
Calibration is underway for other priority water quality components, including bacteria, metals, and (potentially) some organic compounds. Calibration for these parameters will be addressed in the next iteration of this document.

Table 4-1. NSR EFDC model refinement tasks (post-TetraTech model development).

Item	Priority	Status	Recommendations	Target for Completion
Algal dynamics: a). further refine coefficient values (e.g., temperature, light, nutrient effects on algal growth, etc.) to improve calibration; b). include macrophyte group, if needed, based on iterative benthic calibration; and c). potentially include additional benthic algal groups to better represent seasonal succession, based on results from (a).	1	Ongoing		December, 2009
Sediment oxygen demand:: Implement user-defined areal variability in SOD.	1	Ongoing		December, 2009
Bacteria: Calibrate model for bacteria (fecal c., Ecoli).	1	Ongoing		January, 2010
Metals: Calibrate model for example metals (e.g., Se)	1	Ongoing		January, 2010
Integrate waste treatment (IH) model output: Develop formatting / linkage to utilize output from waste treatment mass balance model developed by engineering consultant. This will enable assessment of waste discharge scenarios in EFDC.	1	To be done, pending mass balance model delivery by consultant.		February, 2010
Near-field modeling: Application of CORMIX to supplement EFDC where finer resolution of plume distribution is needed.	2	To be done, pending mass balance model delivery by consultant.		February, 2010
Cross-channel distribution of loads: Statistical comparisons to resolve differences in across channel.	2	Ongoing	This is being addressed, in part by a contaminant loading evaluation, which is underway	February-March, 2010
Ice model: Evaluate more fully the ice model performance on NSR. Further develop ice model to better represent fractional ice cover as well as thermodynamic, frictional, and chemical effects.	2	Ongoing	Ongoing work on fractional ice cover and radiation (transport of heat and light through ice). Heat transport model to build more fully on CE-QUAL-W2 ice model.	March 2010
Reconcile flow balance: Review the flow adjustment factors used by TetraTech vis a vis flow data from AENV hydrologists, and SWAT model development	3	To be done	This work will be addressed by integrated basin-scale model development, to be completed under contract to NSWA.	April, 2010
Sediment transport and processes: Activate dynamic sediment model in EFDC to evaluate transport and fate of sediments and associated contaminants.	3	To be done		2010
Finer-scale flow calibration: Review the flow calibration at fine time scales (hourly flows) to evaluate effects of diurnal flow variability induced by dam operations.	4	To be done	This work may be addressed, in part, by integrated basin-scale model development, under contract to NSWA.	2010
Channel geometry: Evaluate potential in model to vary cross-channel depth (e.g., further discretization of individual lateral cells?). This may improve lateral mixing predictions and benthic algal calibration. Assess level of effort required for this vs. need/potential improvement in model predictions.	4	To be done as needed, pending further calibration of algal dynamics and thermodynamics.		2010
Lateral mixing evaluation: a). Compare lateral mixing coefficients derived from existing empirical studies (e.g., Van der Vinne) to EFDC-predicted lateral mixing.	n/a	Completed using available data.	Dye/tracer studies needed to better constrain near-field mixing processes	Completed
Reconcile positions of data collection/calibration sites: re: position across channel (left - right bank)	n/a	Completed using available data.		Completed
Temperature calibration: Re-calculate solar radiation values, based on re-evaluation of heat transport processes in model. Update temperature calibration.	n/a	Completed		Completed
Update point source loading values and update model calibration: Integrate AENV and external data, not included in original model	n/a	Completed		Completed

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Appendix A. Monitoring Data used for Model Setup and Calibration

The following table outlines the model input files and their data sources. All input data are available from the authors on request.

EFDC Input Filename	Description of Data contained in file	Data Source
WQPSL.INP	Time series mass load for each water quality constituent at each flow boundary or point source input.	2007/2008 survey by AENV, Data provided by City of Edmonton (2000 -2008), Golder (2005).
QSER.INP	Flow time series data at flow specified model boundaries and point source locations	Environment Canada National Water Data Archive (HYDAT) – Water Survey of Canada (WSC)
ASER.INP	Meteorological time series data	Environment Canada National Climate Data and Information Archive
QCTLCK.INP	Downstream outflow boundary condition – stage discharge relationship	Environment Canada National Water Data Archive (HYDAT) – Water Survey of Canada (WSC)
TSER.INP	Temperature time series data at upstream boundary.	Alberta Environment Water Data System (WDS) and Environmental Management System (EMS) database.
WSER.INP	Meteorological time series data.	Environment Canada National Climate Data and Information Archive
DXDY.INP	Horizontal cell lengths, widths, depths, bottom roughness	GIS files for river length and widths. 2007 HEC-RAS model cross-section data are used to get river depth

		for the reach between Edmonton and Fort Saskatchewan and the 1990 cross-section data to get river depths for the portion downstream of Fort Saskatchewan to the Saskatchewan Border.
LXLY.INP	Horizontal cell size location, orientation relative to E-W, NS direction	The locations are derived by visually comparing cross-section location in map.
WQ3DWC.INP	Point source loading locations	Responses to questionnaire sent out by AENV, and available information in WDS.
ICECOVER.INP	Specification of ice cover during the simulation period (present or absent).	Environment Canada National Water Data Archive (HYDAT) – Water Survey of Canada (WSC) and data available in WDS
MALCALGMP.INP	(shading for Algae)	Literature (default) values

Appendix B. Description of Time Series Error Measures

A variety of time series error measures have been used to quantify model performance (US EPA, 1990; Tetra Tech, 2006d). Three widely used error measures are defined here. Using O to denote observations and P to denote model predictions at the corresponding locations and times, the means of the observed and predicted variables for N observations at a single or multiple observation stations is given by:

$$\bar{O} = \frac{1}{N} \sum_{n=1}^{N} O_n \qquad\qquad (A.1)$$

$$\bar{P} = \frac{1}{N} \sum_{n=1}^{N} P_n \qquad\qquad (A.2)$$

The mean error of the model predictions is given by:

$$ME = \bar{P} - \bar{O} \qquad\qquad (A.3)$$

and is often referred to as the mean bias error (MBE) and also written as observed minus predicted. Tabulation of the observed and predicted means is an alternate to eliminating confusion regarding the sign convention. The mean error is a measure of systematic model over or under prediction. It is noted that the *MBE* can be small in situations where there is large disagreement between predictions and observations. The mean absolute error:

$$MAE = \frac{1}{N} \sum_{n=1}^{N} |P_n - O_n| \qquad\qquad (A.4)$$

And the root mean square error:

$$RMSE = \sqrt{\frac{1}{N} \sum_{n=1}^{N} (P_n - O_n)^2} \qquad\qquad (A.5)$$

provide measures of the average differences between predictions and observations without regard to over or under prediction. Normalization of the MBE, MAE and RMSE is often useful in facilitating the comparison of model performance between different application sites. The mean error may be normalized to define a fractional or relative mean error:

$$RME = \frac{\bar{P} - \bar{O}}{\bar{O}} \qquad\qquad (A.6)$$

with the choice of the denominator not being unique in the literature. The choice for normalization of the MAE is even less unique. Two possible choices are:

$$RMAE_O = \frac{MAE}{\overline{O}} \qquad (A.7a)$$

$$RMAE_{|o|} = \frac{MAE}{\frac{1}{N}\sum_{n=1}^{N}|O_n|} \qquad (A.7b)$$

which are equivalent for positive observation variables. A logical choice for the fractional or relative RMSE is:

$$FRMSE = \frac{RMSE}{\sqrt{\frac{1}{N}\sum_{n=1}^{N}O_n^2}} \qquad (A.8)$$

Additional error measures are summarized in Tetra Tech (2006d).

Appendix C. Water Temperature Plots

Note: Blue points indicate modelled data; Red points indicate observed data.
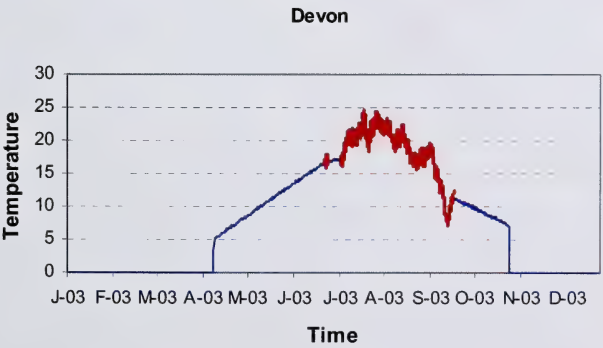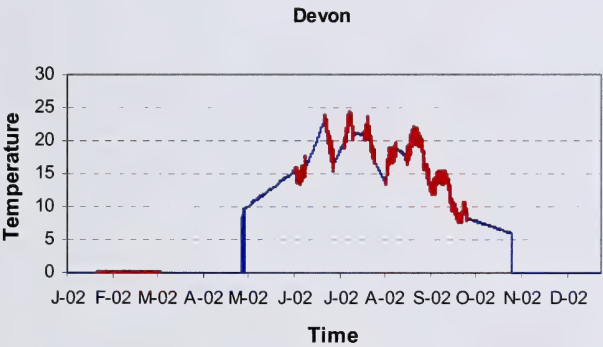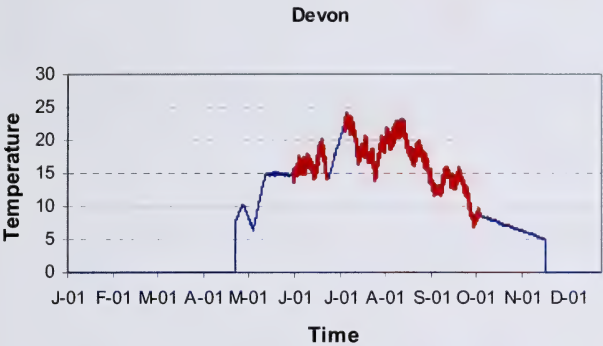
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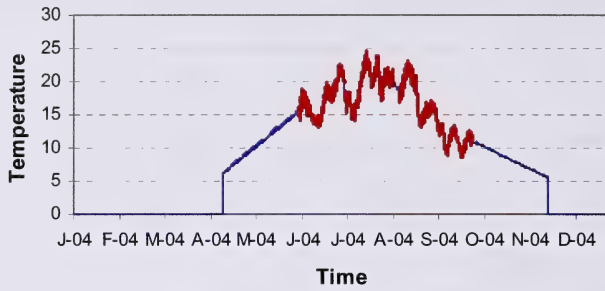
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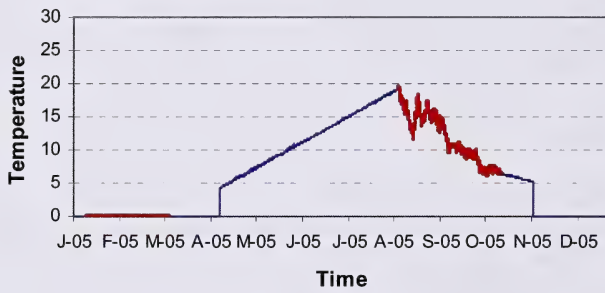
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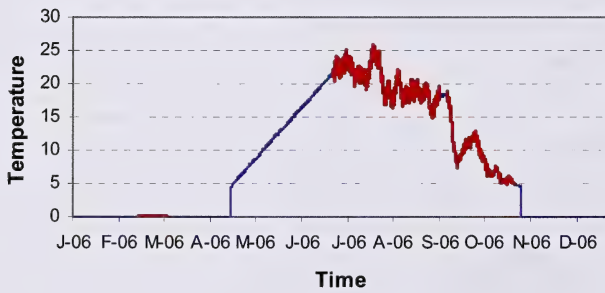
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Devon

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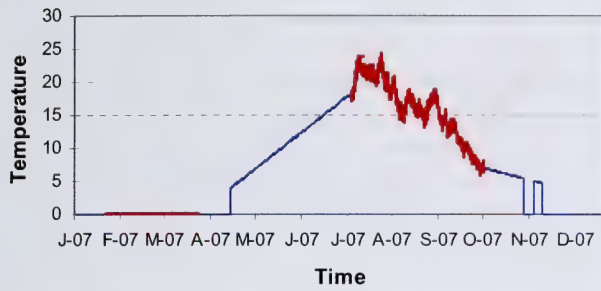
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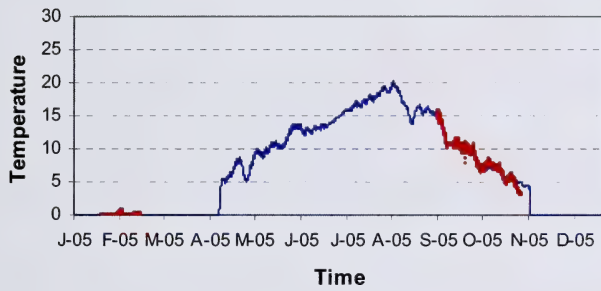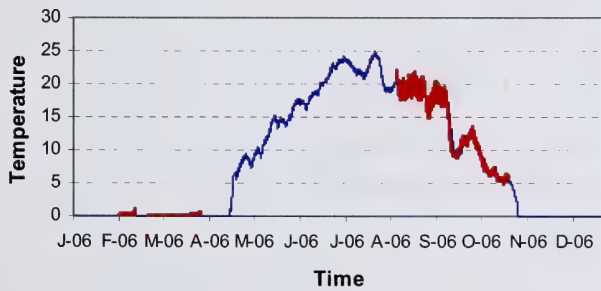
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Upstream of Capital Region WWTP
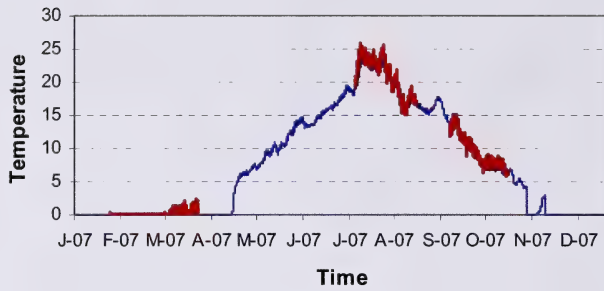
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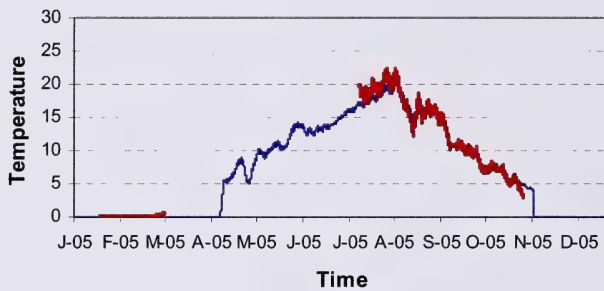
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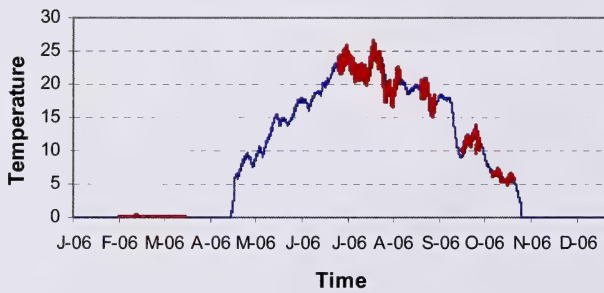
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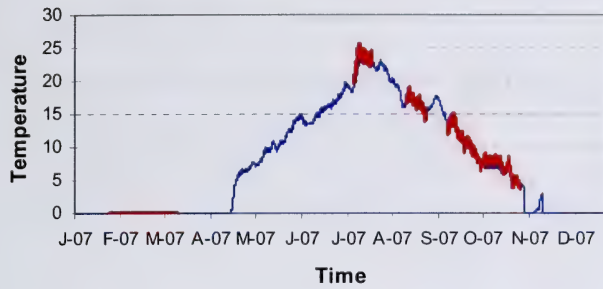
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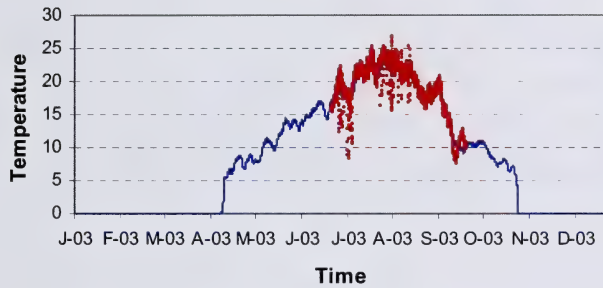
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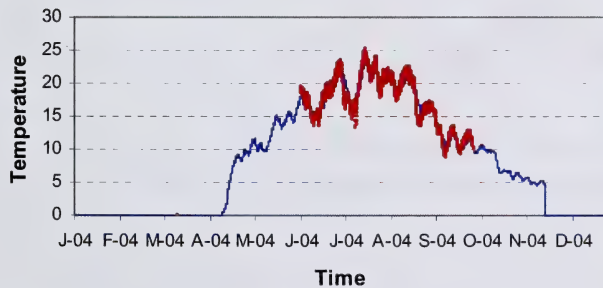
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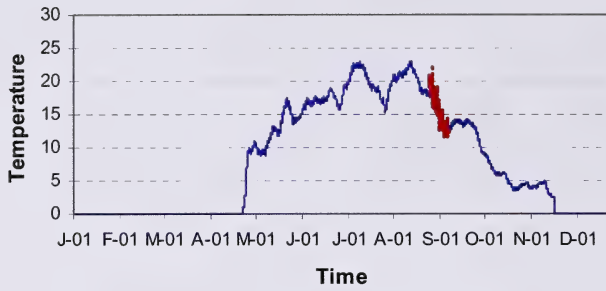
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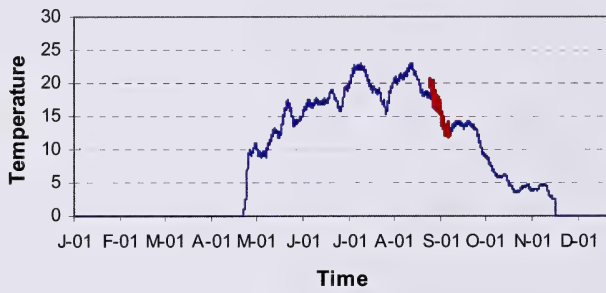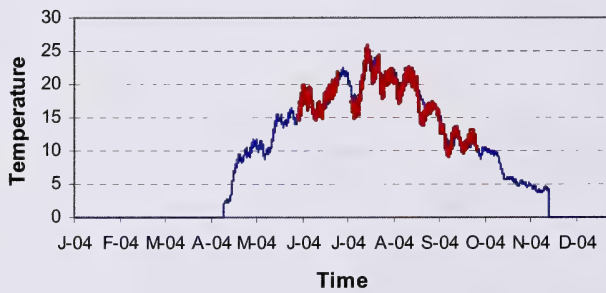
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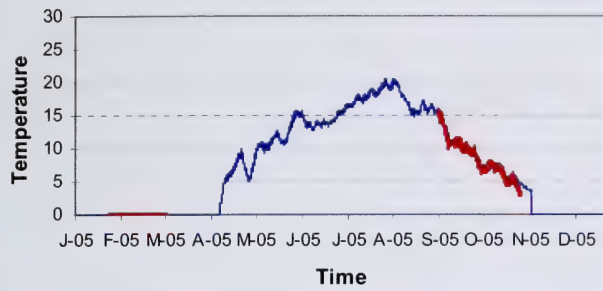
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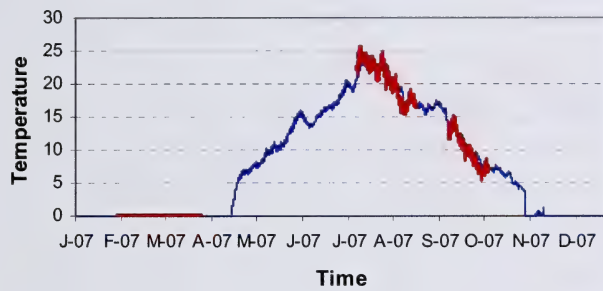
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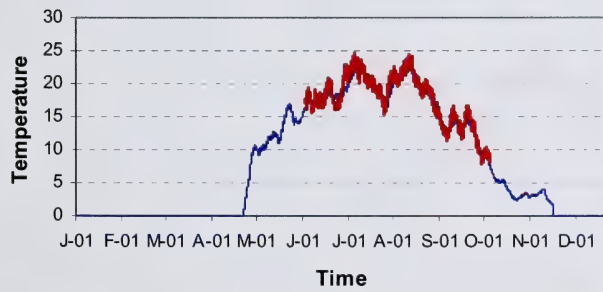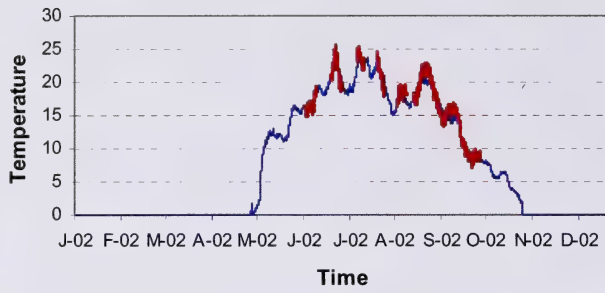
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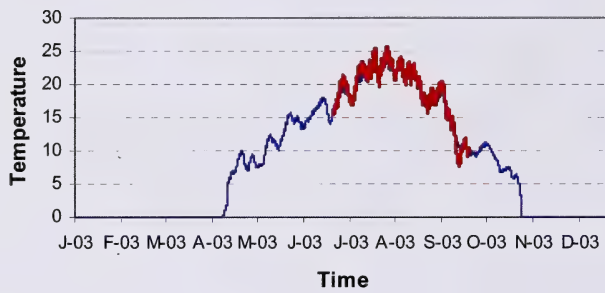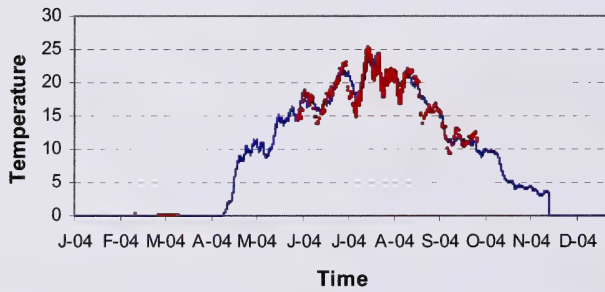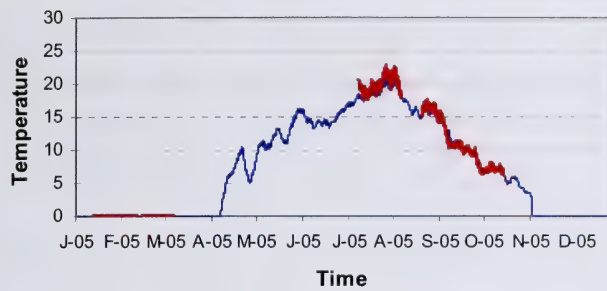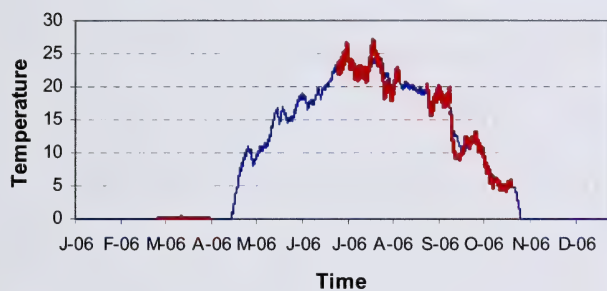
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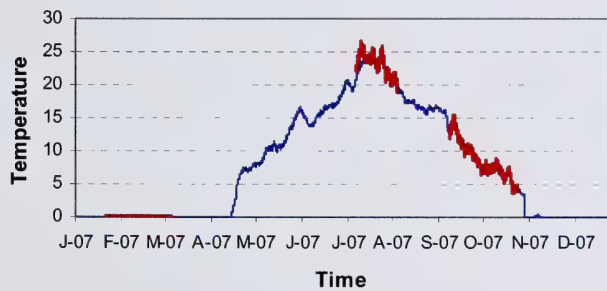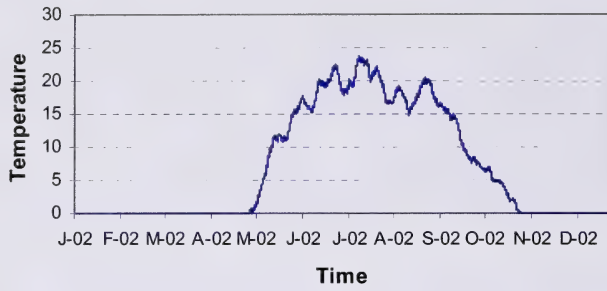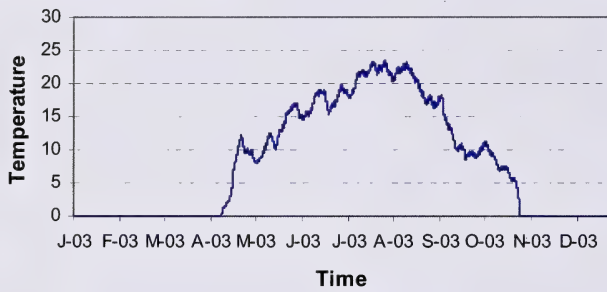
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Lea Park

Lea Park
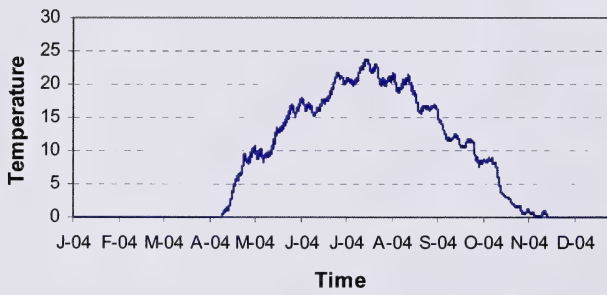
Appendix D. Loading Estimations

Extensive data assembly and analysis was conducted to support the set-up of the EFDC model. This Appendix summarizes existing ("baseline") loading values by discharger and by sector on inter-annual and seasonal timescales. This data is provided for illustrative purposes, and values are given for a limited suite of parameters (total phosphorus and ammonia). However, data are available for all parameters included in the water quality dataset

A simple summary of loads for other parameters is provided at the end of this appendix. Upcoming reports will document a more detailed evaluation of contaminant loads in the NSR, which is underway.

Loading (Flux) Calculations (kg/day)
Annual 2000-05

	TP							Ammonia Nitrogen						
	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP
NSR @ Devon	869.7							308.9						
Devon Sewage Treatment Plant							5.7							2.1
GoldBar WWTP		117.0							1739.6					
GoldBar Combined Bypass		30.7							91.4					
Capital Region WWTP			180.8							1744.1				
Celanese N				0.3							0.2			
Celanese South				0.3							0.2			
Gulf Chemicals - Effluent "A" Discharge				0.0							0.0			
Agrium Redwater				4.3							10.2			
Air Liquide Scotford				0.1							0.2			
Alta Steel Ltd.				0.0							0.1			
AT Plastics Inc.				0.0							0.1			
Degussa Canada Inc. Gibbons				0.8							0.1			
Geon Canada Inc.				0.0							0.8			
Imperial Oil				5.6							1.7			
Owens-Corning Canada Inc. - Wastewater				0.0							0.2			
Owens-Corning Canada Inc. - Sanitary sewage				0.0							0.0			
Petro-Canada Products				4.8							2.1			
Raylo Chemicals Inc.														
Shell Canada Limited - Scotford Refinery				0.8							0.8			
Scotford Upgrader Clean Stormwater Pond Release				0.0							1.6			
Scotford Upgrader Effluent Pond Discharge				7.7							1.0			
Shell -Styrene Monomer (SM) plant discharge				5.6							1.1			
Shell -Ethylene Glycol (MEG) plant discharge				4.7							6.4			
Viridian Fort Saskatchewan				0.0							153.4			
Edmonton - Kennedale Storm Sewer					9.0							15.5		
Edmonton - Groat Road Storm Sewer					4.5							4.6		
Edmonton - Quesnell Storm Sewer					18.3							25.5		
Edmonton- 30th Avenue Storm					24.2							60.7		
Edmonton - Whitemud Ck					3.2							5.6		
Edmonton - Horse Hill Ck					1.2							5.6		
Edmonton - Wedgewood Ck					3.2							5.6		
Edmonton - Belgravia					2.0							4.1		
Edmonton - Mill Creek					7.0							10.9		
Edmonton - Rat Creek CSO					16.4							38.8		
Edmonton - Highland CSO					0.7							1.7		
Edmonton - Capilano CSO					0.4							0.7		
Edmonton - Remaining CSO					0.3							0.6		
ELSmith WTP						6.8							1.1	
Rossdale WTP						2.8							2.1	
SUM	870	148	181	35	90	10	6	309	1831	1744	180	180	3	2
Fraction (%)	65%	11%	14%	3%	7%	1%	0%	7%	43%	41%	4%	4%	0%	0%
Total	1339							4249						

Loading (Flux) Calculations (kg/day) Annual 2000-08

	TP							Ammonia Nitrogen						
	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP
NSR @ Devon	1216.0							414.6						
Devon Sewage Treatment Plant							5.7							34.7
GoldBar WWTP		218.4							1398.1					
GoldBar Combined Bypass		38.4							114.4					
Capital Region WWTP			168.8							1335.2				
Celanese N				0.3							0.2			
Celanese South				0.3							0.2			
Gulf Chemicals - Effluent "A" Discharge				0.0							0.0			
Agrium Redwater				4.2							9.9			
Air Liquide Scotford				0.1							0.2			
Alta Steel Ltd.				0.1							0.1			
AT Plastics Inc.				0.0							0.3			
Degussa Canada Inc. Gibbons				0.7							0.1			
Geon Canada Inc.				0.0							0.8			
Imperial Oil				6.0							1.7			
Owens-Corning Canada Inc. - Wastewater				0.0							0.2			
Owens-Corning Canada Inc. - Sanitary sewage				0.0							0.0			
Petro-Canada Products				5.0							2.2			
Raylo Chemicals Inc.														
Shell Canada Limited - Scotford Refinery				0.8							0.8			
Scotford Upgrader Clean Stormwater Pond Release				0.0							2.0			
Scotford Upgrader Effluent Pond Discharge				11.2							1.1			
Shell -Styrene Monomer (SM) plant discharge				5.1							1.3			
Shell -Ethylene Glycol (MEG) plant discharge				4.6							6.2			
Viridian Fort Saskatchewan				0.0										
Edmonton - Kennedale Storm Sewer					9.7							14.6		
Edmonton - Groat Road Storm Sewer					7.7							11.0		
Edmonton - Quesnell Storm Sewer					15.8							20.8		
Edmonton - 30th Avenue Storm					23.3							58.2		
Edmonton - Whitemud Ck					3.5							5.5		
Edmonton - Horse Hill Ck					3.5							5.5		
Edmonton - Wedgewood Ck					3.5							5.5		
Edmonton - Belgravia					4.7							7.0		
Edmonton - Mill Creek					6.7							10.1		
Edmonton - Rat Creek CSO					15.3							37.3		
Edmonton - Highland CSO					0.8							1.7		
Edmonton - Capilano CSO					0.6							1.1		
Edmonton - Remaining CSO					0.3							0.7		
ELSmith WTP						6.7							1.1	
Rossdale WTP						2.8							2.1	
SUM	1216	257	169	38	95	10	6	415	1513	1335	27	179	3	35
Fraction (%)	68%	14%	9%	2%	5%	1%	0%	12%	43%	38%	1%	5%	0%	1%
Total	1790							3507						

Loading (Flux) Calculations (kg/day)
Jan-Mar (06-08)

	TP							Ammonia Nitrogen						
	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP
NSR @ Devon	159.0							310.0						
Devon Sewage Treatment Plant							5.5							26.3
GoldBar WWTP		86.9							1007.4					
GoldBar Combined Bypass		38.4							117.2					
Capital Region WWTP			207.7							396.7				
Celanese N				0.3							0.2			
Celanese South				0.3										
Gulf Chemicals - Effluent "A" Discharge				0.0							0.0			
Agrium Redwater				4.0							10.0			
Air Liquide Scotford				0.1							0.2			
Alta Steel Ltd.				0.1							0.1			
AT Plastics Inc.				0.0							0.5			
Degussa Canada Inc. Gibbons				0.6							0.1			
Geon Canada Inc.				0.0							0.3			
Imperial Oil				5.8							1.7			
Owens-Corning Canada Inc. - Wastewater				0.0							0.2			
Owens-Corning Canada Inc. - Sanitary sewage				0.0							0.0			
Petro-Canada Products				4.3							3.3			
Raylo Chemicals Inc.														
Shell Canada Limited - Scotford Refinery				0.6							1.7			
Scotford Upgrader Clean Stormwater Pond Release				0.0							3.0			
Scotford Upgrader Effluent Pond Discharge				13.7							1.1			
Shell -Styrene Monomer (SM) plant discharge				4.3							2.5			
Shell -Ethylene Glycol (MEG) plant discharge				4.7							6.3			
Viridian Fort Saskatchewan				0.0										
Edmonton - Kennedale Storm Sewer					11.1							11.1		
Edmonton - Groat Road Storm Sewer					10.3							18.3		
Edmonton - Quesnell Storm Sewer					7.2							9.8		
Edmonton-30th Avenue Storm					23.3							71.2		
Edmonton - Whitemud Ck					3.1							5.6		
Edmonton - Horse Hill Ck					1.2							5.4		
Edmonton - Wedgewood Ck					3.1							5.6		
Edmonton - Belgravia					7.6							11.6		
Edmonton - Mill Creek					2.1							3.2		
Edmonton - Rat Creek CSO					1.2							3.9		
Edmonton - Highland CSO					0.0							0.0		
Edmonton - Capilano CSO					0.0							0.0		
Edmonton - Remaining CSO					0.0							0.0		
ELSmith WTP						1.8							0.8	
Rossdale WTP						2.4							2.1	
SUM	159	125	208	39	70	4	5	310	1125	397	31	146	3	26
Fraction (%)	26%	21%	34%	6%	11%	1%	1%	15%	55%	19%	2%	7%	0%	1%
Total	610							2037						

Loading (Flux) Calculations (kg/day)
April-June (06-08)

	TP							Ammonia Nitrogen						
	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP
NSR @ Devon	6600.4							1296.3						
Devon Sewage Treatment Plant							5.5							29.4
GoldBar WWTP		112.8							564.8					
GoldBar Combined Bypass		106.4							305.9					
Capital Region WWTP			241.4							439.1				
Celanese N				0.3							0.0			
Celanese South											0.2			
Gulf Chemicals - Effluent "A" Discharge				0.0							0.0			
Agrium Redwater				4.6							10.8			
Air Liquide Scotford				0.1							0.2			
Alta Steel Ltd.				0.1							0.3			
AT Plastics Inc.				0.0							1.0			
Degussa Canada Inc. Gibbons				0.8							0.1			
Geon Canada Inc.				0.0							0.3			
Imperial Oil				7.2							3.2			
Owens-Corning Canada Inc. - Wastewater				0.0							0.2			
Owens-Corning Canada Inc. - Sanitary sewage				0.0							0.0			
Petro-Canada Products				5.4							2.2			
Raylo Chemicals Inc.														
Shell Canada Limited - Scotford Refinery				0.8							0.6			
Scotford Upgrader Clean Stormwater Pond Release				0.0							3.0			
Scotford Upgrader Effluent Pond Discharge				14.0							1.4			
Shell -Styrene Monomer (SM) plant discharge				4.0							1.4			
Shell -Ethylene Glycol (MEG) plant discharge				4.3							5.8			
Viridian Fort Saskatchewan				0.0										
Edmonton - Kennedale Storm Sewer					17.0							16.0		
Edmonton - Groat Road Storm Sewer					23.8							31.0		
Edmonton - Quesnell Storm Sewer					14.0							9.0		
Edmonton - 30th Avenue Storm					23.0							35.2		
Edmonton - Whitemud Ck					8.8							7.5		
Edmonton - Horse Hill Ck					1.2							5.4		
Edmonton - Wedgewood Ck					8.8							7.5		
Edmonton - Belgravia					23.4							27.6		
Edmonton - Mill Creek					8.7							10.7		
Edmonton - Rat Creek CSO					25.3							67.2		
Edmonton - Highland CSO					2.1							4.8		
Edmonton - Capilano CSO					1.8							3.5		
Edmonton - Remaining CSO					0.7							1.7		
ELSmith WTP						8.5							1.2	
Rossdale WTP						3.0							2.3	
SUM	6600	219	241	42	159	11	5	1296	871	439	31	227	4	29
Fraction (%)	91%	3%	3%	1%	2%	0%	0%	45%	30%	15%	1%	8%	0%	1%
Total	7278							2897						

Loading (Flux) Calculations (kg/day)
July - Sep (06-08)

	TP							Ammonia Nitrogen						
	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP
NSR @ Devon	167.0							641.7						
Devon Sewage Treatment Plant							5.7							47.4
GoldBar WWTP		92.4							128.5					
GoldBar Combined Bypass		60.8							190.6					
Capital Region WWTP			223.2							278.2				
Celanese N				0.3							0.0			
Celanese South				0.3										
Gulf Chemicals - Effluent "A" Discharge				0.0							0.0			
Agrium Redwater				3.4							7.8			
Air Liquide Scotford				0.2							0.2			
Alta Steel Ltd.				0.1							0.2			
AT Plastics Inc.				0.0							0.9			
Degussa Canada Inc. Gibbons				0.7							0.1			
Geon Canada Inc.				0.0							0.3			
Imperial Oil				8.0							1.2			
Owens-Corning Canada Inc. - Wastewater				0.0							0.2			
Owens-Corning Canada Inc. - Sanitary sewage				0.0							0.0			
Petro-Canada Products				5.7							0.7			
Raylo Chemicals Inc.														
Shell Canada Limited - Scotford Refinery				0.8							0.3			
Scotford Upgrader Clean Stormwater Pond Release				0.0							3.0			
Scotford Upgrader Effluent Pond Discharge				13.8							0.7			
Shell -Styrene Monomer (SM) plant discharge				4.2							0.9			
Shell -Ethylene Glycol (MEG) plant discharge				3.7							5.0			
Viridian Fort Saskatchewan				0.0										
Edmonton - Kennedale Storm Sewer					10.4							14.7		
Edmonton - Groat Road Storm Sewer					16.6							23.2		
Edmonton - Quesnell Storm Sewer					11.8							12.3		
Edmonton- 30th Avenue Storm					20.5							37.5		
Edmonton - Whitemud Ck					3.0							4.1		
Edmonton - Horse Hill Ck					1.2							5.4		
Edmonton - Wedgewood Ck					3.0							4.1		
Edmonton - Belgravia					7.9							8.6		
Edmonton - Mill Creek					10.7							14.7		
Edmonton - Rat Creek CSO					22.3							60.3		
Edmonton - Highland CSO					1.2							2.7		
Edmonton - Capilano CSO					2.6							4.7		
Edmonton - Remaining CSO					0.5							1.3		
ELSmith WTP						11.8							1.4	
Rossdale WTP						3.1							2.1	
SUM	167	153	223	41	112	15	6	642	319	278	22	194	4	47
Fraction (%)	23%	21%	31%	6%	16%	2%	1%	43%	21%	18%	1%	13%	0%	3%
Total	717							1505						

Loading (Flux) Calculations (kg/day)
Oct - Dec (06-08)

	TP							Ammonia Nitrogen						
	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP	NSR @ Devon	GoldBar WWTP	CRWWTP	Industries	Storm Sewers	WTP	Devon WWTP
NSR @ Devon	106.9							317.3						
Devon Sewage Treatment Plant							6.0							36.6
GoldBar WWTP		60.8							412.4					
GoldBar Combined Bypass		7.0							24.8					
Capital Region WWTP			217.0							232.7				
Celanese N				0.3							0.2			
Celanese South				0.3							0.0			
Gulf Chemicals - Effluent "A" Discharge				0.0							0.0			
Agrium Redwater				3.6							7.1			
Air Liquide Scotford				0.1							0.2			
Alta Steel Ltd.				0.1							0.1			
AT Plastics Inc.				0.0							0.6			
Degussa Canada Inc. Gibbons				0.5							0.1			
Geon Canada Inc.				0.0							0.3			
Imperial Oil				6.2							0.8			
Owens-Corning Canada Inc. - Wastewater				0.0							0.2			
Owens-Corning Canada Inc. - Sanitary sewage				0.0							0.0			
Petro-Canada Products				4.3							3.0			
Raylo Chemicals Inc.														
Shell Canada Limited - Scotford Refinery				0.5							0.7			
Scotford Upgrader Clean Stormwater Pond Release				0.0							3.0			
Scotford Upgrader Effluent Pond Discharge				14.2							3.2			
Shell -Styrene Monomer (SM) plant discharge				4.4							2.6			
Shell -Ethylene Glycol (MEG) plant discharge				4.2							5.6			
Viridian Fort Saskatchewan				0.0										
Edmonton - Kennedale Storm Sewer					3.4							6.9		
Edmonton - Groat Road Storm Sewer					8.2							34.6		
Edmonton - Quesnell Storm Sewer					5.0							7.0		
Edmonton-30th Avenue Storm					15.2							64.2		
Edmonton - Whitemud Ck					1.2							3.3		
Edmonton - Horse Hill Ck					1.2							0.0		
Edmonton - Wedgewood Ck					1.2							3.3		
Edmonton - Belgravia					1.3							3.8		
Edmonton - Mill Creek					3.0							5.7		
Edmonton - Rat Creek CSO					0.1							0.3		
Edmonton - Highland CSO					0.0							0.0		
Edmonton - Capilano CSO					0.0							0.0		
Edmonton - Remaining CSO					0.0							0.0		
ELSmith WTP						5.2							1.0	
Rossdale WTP						2.7							2.1	
SUM	107	68	217	39	40	8	6	317	437	233	28	129	3	37
Fraction (%)	22%	14%	45%	8%	8%	2%	1%	27%	37%	20%	2%	11%	0%	3%
Total	484							1184						

Summary of point-source and tributary loads (kg/day; averaged over the period of simulation (2000-2007); nitrogen species given as N).

Name of Source	TOC[a]	DOC[a]	TKN[a]	Nitrite+ Nitrate	Ammonia	TP[a]	TDP[a]
Industrial Point source loads							
Celanese Canada Inc. South Flume Effluent	59.4	36.5	1.8	2.3	0.2	0.3	0.0
Celanese Canada Inc. North Flume Effluent	59.4	36.5	1.8	2.3	0.2	0.3	0.0
Dow Chemical Canada Inc. - Ft. Sask. Chemical Plant	199.4	193.5	12.9	1.0	2.6	7.5	6.2
Gulf Chemicals - Effluent "A" Discharge	21.7	21.0	0.0	0.0	0.0	0.0	0.0
Agrium Redwater	51.0	48.5	17.9	13.6	10.1	4.2	3.6
Air Liquide Scotford	3.2	2.7	0.3	0.2	0.2	0.1	0.1
Alta Steel Ltd.	8.6	7.8	1.1	0.1	0.1	0.1	0.0
AT Plastics Inc.	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Degussa Canada Inc. Gibbons	3.8	3.1	0.5	0.6	0.1	0.7	0.7
Geon Canada Inc.	6.9	5.5	0.0	0.0	0.8	0.0	0.0
Imperial Oil	89.0	71.2	9.0	1.2	1.8	5.8	4.8
Owens-Corning Canada Inc. - Wastewater	0.3	0.2	0.0	0.0	0.2	0.0	0.0
Owens-Corning Canada Inc. - Sanitary sewage	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petro-Canada Products	10.8	9.0	7.0	3.2	2.2	4.9	2.9
Raylo Chemicals Inc.	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Shell Canada Limited - Scotford Refinery	5.0	2.8	1.8	1.2	0.8	0.8	0.5
Scotford Upgrader Clean Stormwater Pond Release	23.3	19.6	0.0	0.0	1.9	0.0	0.0
Scotford Upgrader Effluent Pond Discharge	9.1	7.6	7.8	24.9	1.0	8.9	7.9
Shell -Styrene Monomer (SM) plant discharge	32.2	25.7	3.3	3.0	1.2	5.5	4.3
Shell -Ethylene Glycol (MEG) plant discharge	63.0	42.8	10.2	7.1	6.2	4.6	3.6
Viridian Fort Saskatchewan	11.6	9.3	161.6	102.0	153.4	0.0	0.0
Total - Industrial	**657.9**	**543.7**	**237.0**	**162.6**	**183.1**	**43.7**	**34.6**
Wastewater Treatment Plant Point source loads							
Capital region WWTP	998.1	678.9	1542.6	376.5	1481.1	189.0	183.0
Devon Sewage Treatment Plant	32.3	23.7	41.4	8.8	34.7	5.7	5.4
Gold Bar Sewage Treatment Plant	3130.0	2458.4	2166.2	1528.4	1565.9	222.1	111.1
Gold Bar Combined Bypass	465.4	363.9	162.2	3.9	113.9	38.8	32.6
Elkpoint WWTP	13.1	9.0	22.1	0.4	12.1	2.0	1.7
Total - WWTP	**4638.9**	**3534.0**	**3934.4**	**1918.0**	**3207.7**	**457.6**	**333.8**
Water Treatment Plant Point source loads							
ELSmith WTP	739.1	11.6	33.9	0.3	1.1	6.7	0.0
Rossdale WTP	324.0	11.2	36.0	0.3	2.1	2.8	0.0
Total - Municipal WTP	**1063.1**	**22.8**	**69.9**	**0.6**	**3.3**	**9.4**	**0.1**
Storm Sewers and CSO's Point source loads							
Edmonton - Kennedale Storm Sewer	107.4	46.2	46.8	37.0	15.3	9.7	4.5
Edmonton - Groat Road Storm Sewer	72.6	61.7	25.1	7.1	6.1	5.7	1.8
Edmonton - Quesnell Storm Sewer	182.7	78.6	78.1	35.4	23.4	17.3	9.9
Edmonton- 30th Avenue Storm	238.4	102.5	122.3	78.3	59.4	23.7	16.9
Edmonton - Whitemud Ck	35.3	30.0	16.3	9.7	5.7	3.6	1.9
Edmonton - Horse Hill Ck	35.3	30.0	16.3	9.7	5.7	3.6	1.9
Edmonton - Wedgewood Ck	35.3	30.0	16.3	9.7	5.7	3.6	1.9
Edmonton - Belgravia	34.7	29.5	17.3	13.9	5.4	3.3	1.7
Edmonton - Mill Creek	82.0	69.7	38.0	22.2	11.5	7.6	4.0
Edmonton - Rat Creek CSO	301.8	77.3	92.9	5.2	39.5	16.3	7.2
Edmonton - Highland CSO	14.4	6.2	4.4	0.2	1.8	0.8	0.4
Edmonton - Capilano CSO	9.2	6.4	2.9	0.3	1.0	0.6	0.3
Edmonton - Remaining CSO	5.1	2.2	1.7	0.1	0.7	0.3	0.1
Total - Stormsewers and CSO's	**1154.2**	**570.2**	**478.5**	**228.8**	**181.2**	**96.1**	**52.5**
Tributary loads							
Blackmud Creek	435.2	396.0	29.6	2.4	1.0	1.4	0.7
Whitemud Creek	272.6	248.1	18.5	1.5	0.6	0.9	0.4
Sturgeon River	1926.9	1926.9	199.9	11.9	124.9	5.9	3.9
Redwater River	1018.6	964.6	76.0	0.5	15.6	4.1	1.8
Waskatenau Creek	120.1	69.9	10.9	1.2	0.7	1.7	0.6
Atimsowe Creek	220.8	128.6	19.9	2.3	1.3	3.1	1.1
Moose Hill Creek	67.5	39.3	6.0	0.7	0.4	0.8	0.3
Vermilion River	1927.6	1622.6	175.0	49.9	29.0	16.2	14.8
Total - Tributaries	**7172.0**	**5981.0**	**1023.2**	**299.9**	**358.2**	**132.0**	**76.9**

[a] TOC, total organic carbon; DOC, dissolved organic carbon; TKN, Total Kjeldahl Nitrogen; TP; total phosphorous, TDP; total dissolved phosphorous

Appendix E. Dissolved Oxygen Plots

Note: Blue points indicate modelled data; Red points indicate observed data.
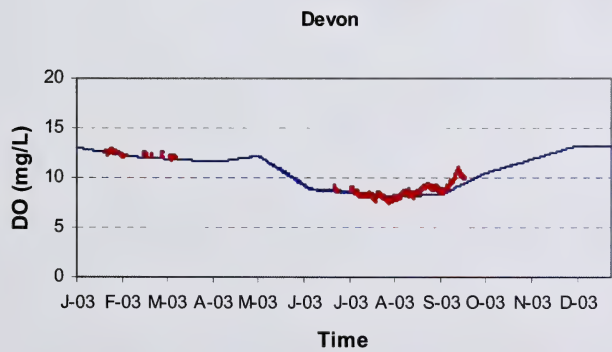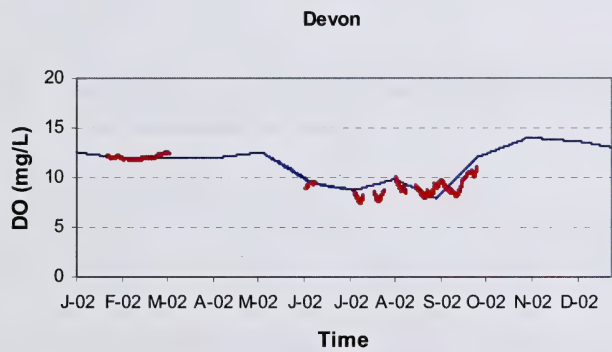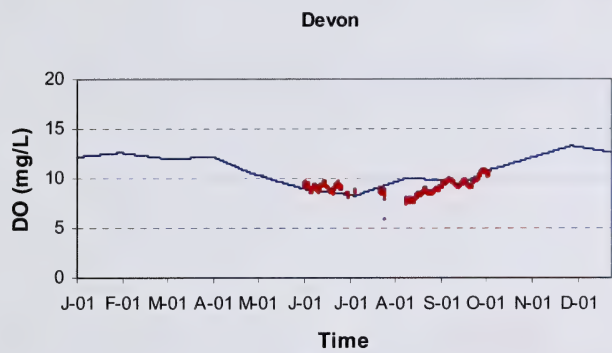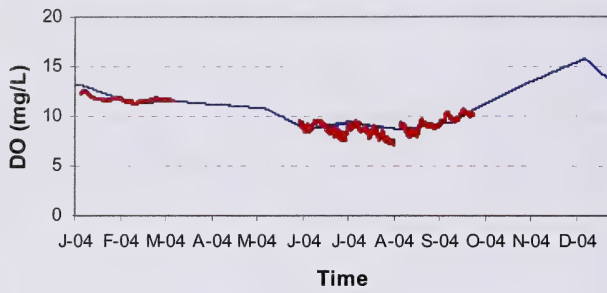
Devon

Devon

Devon

Devon

Devon

Devon

90

Devon

Upstream of Capital Region WWTP

Upstream of Capital Region WWTP

Upstream of Capital Region WWTP

Fort Saskatchewan

Fort Saskatchewan

Fort Saskatchewan

Upstream of HWY 15

Upstream of HWY 15

93

Upstream of RR Trestle

Downstream of RR Trestle

Vinca

94

Vinca

Vinca

Pakan

Pakan

Time

Pakan

Time

Pakan

Time
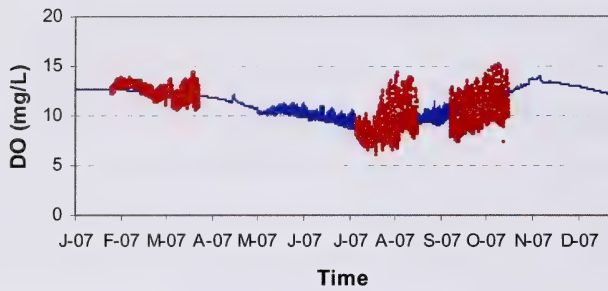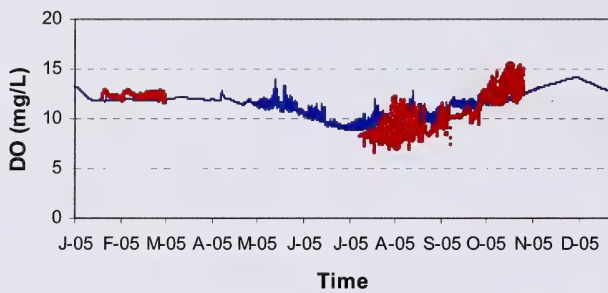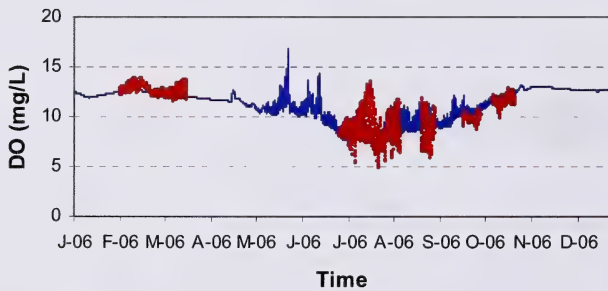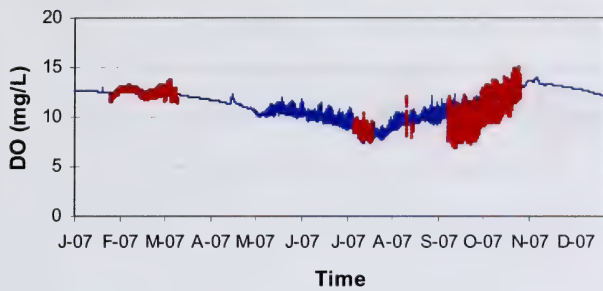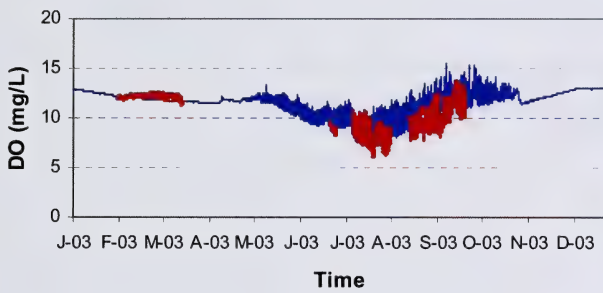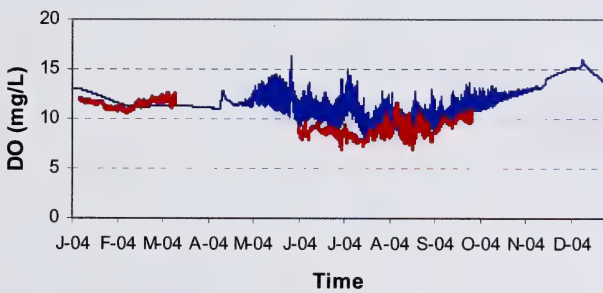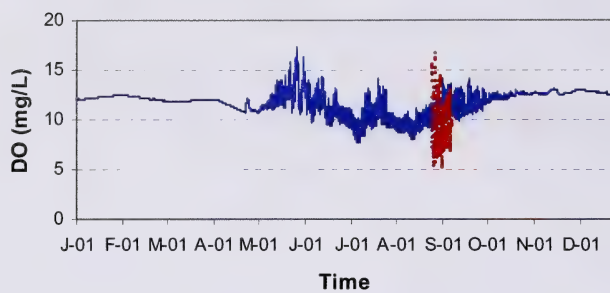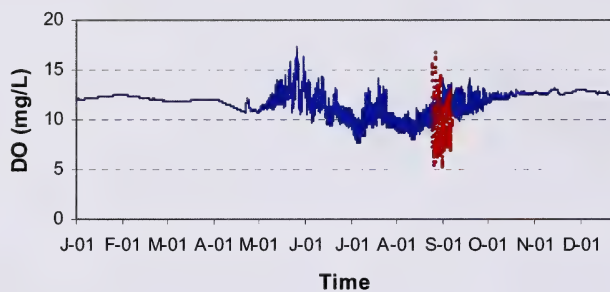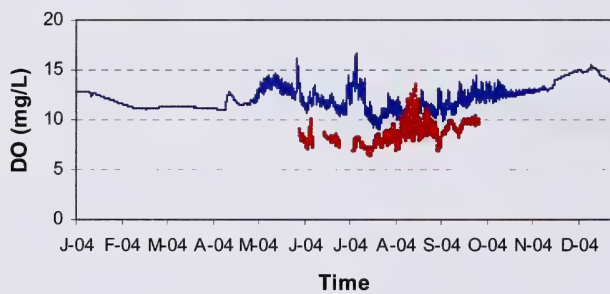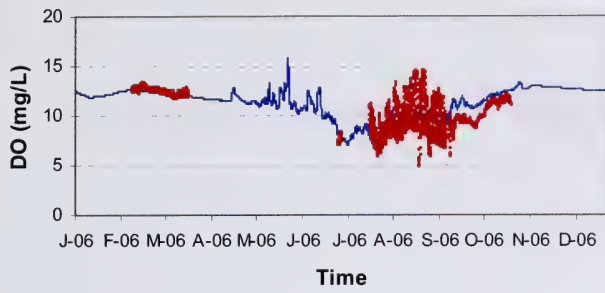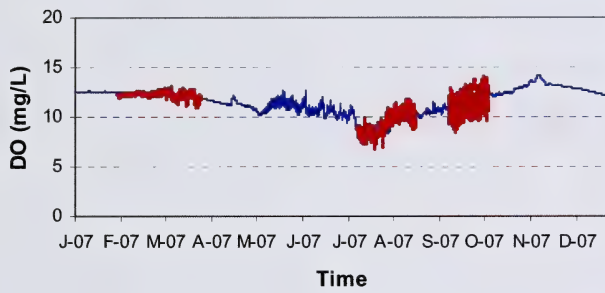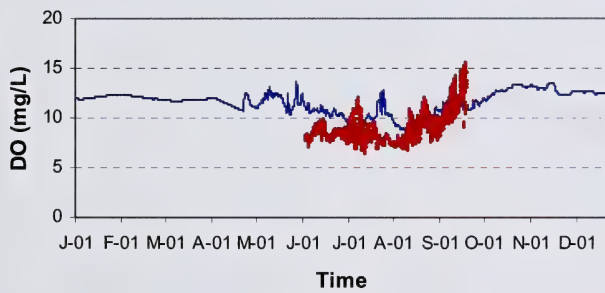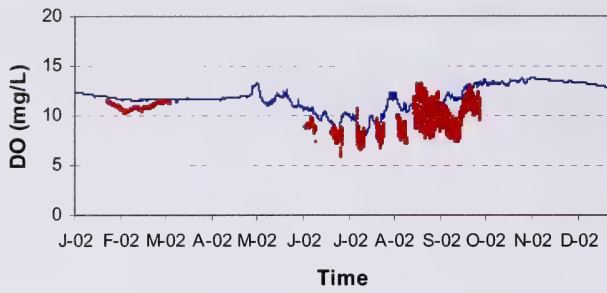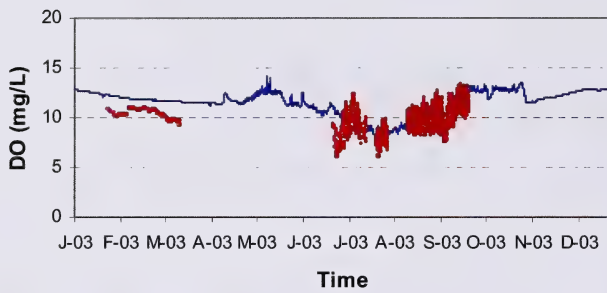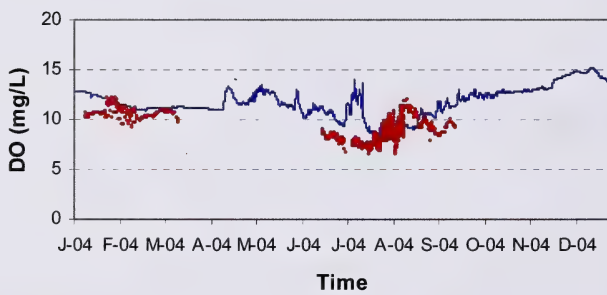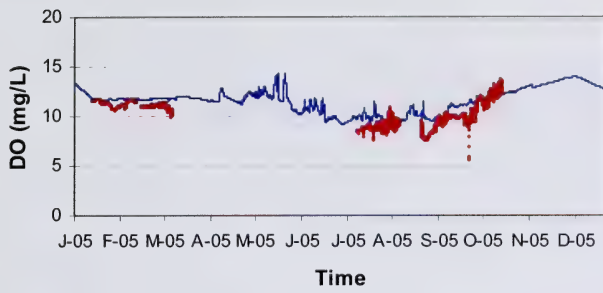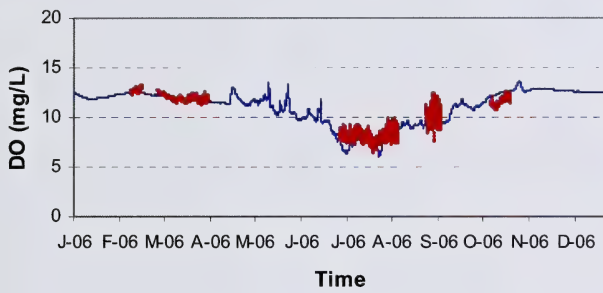
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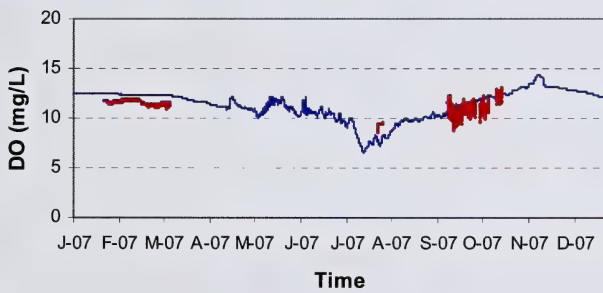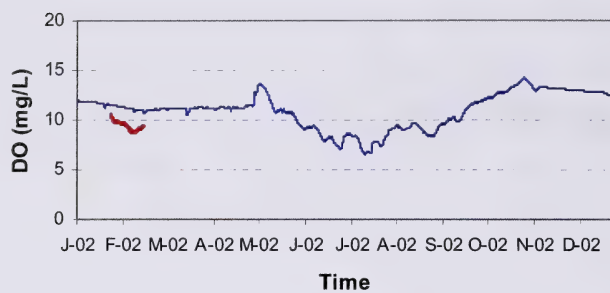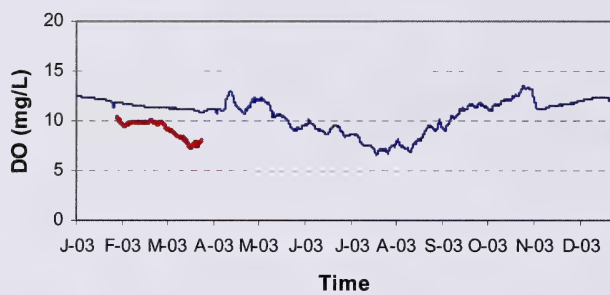
Lea Park

Lea Park

Lea Park
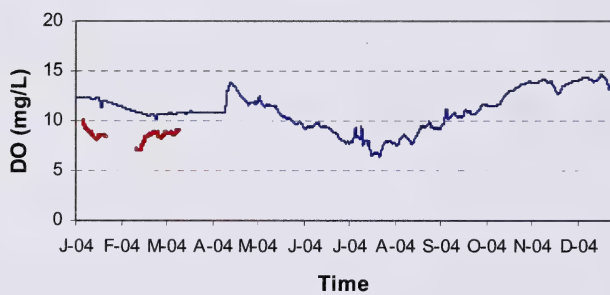
Appendix F. Water Quality Plots and Error Measures

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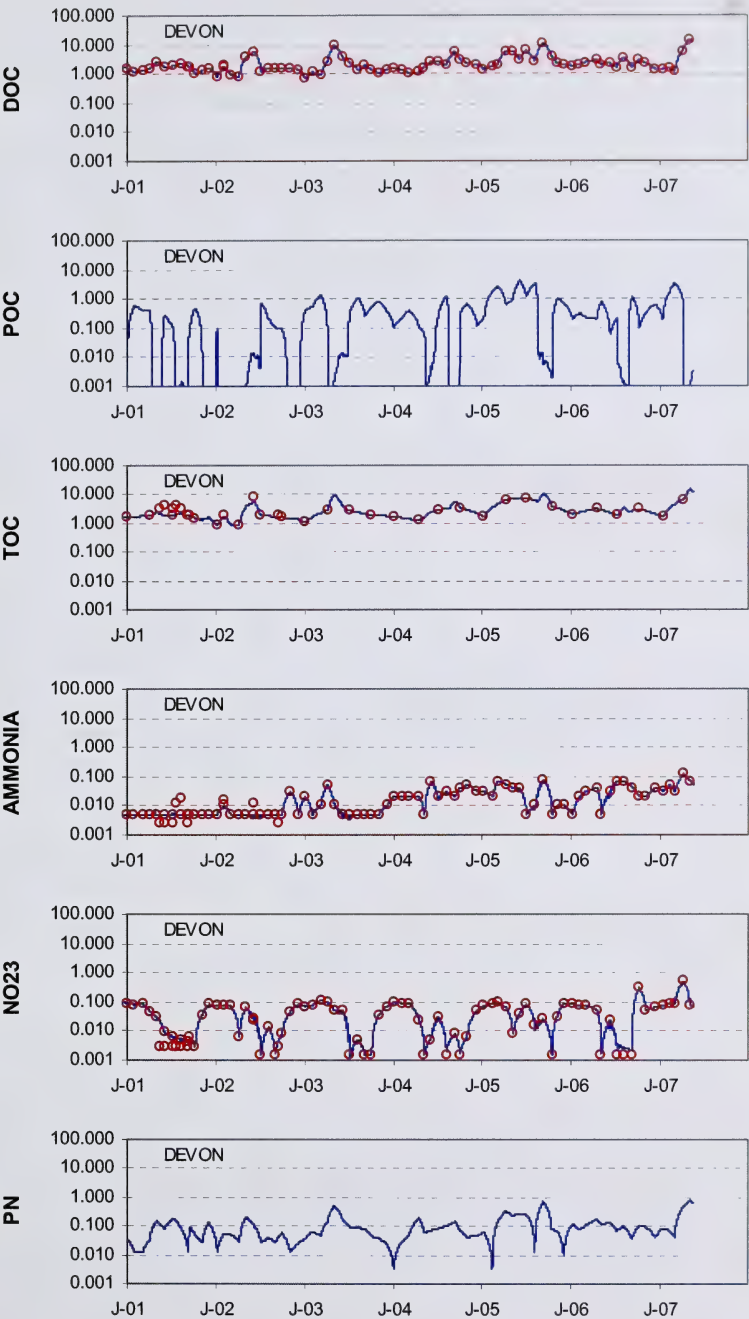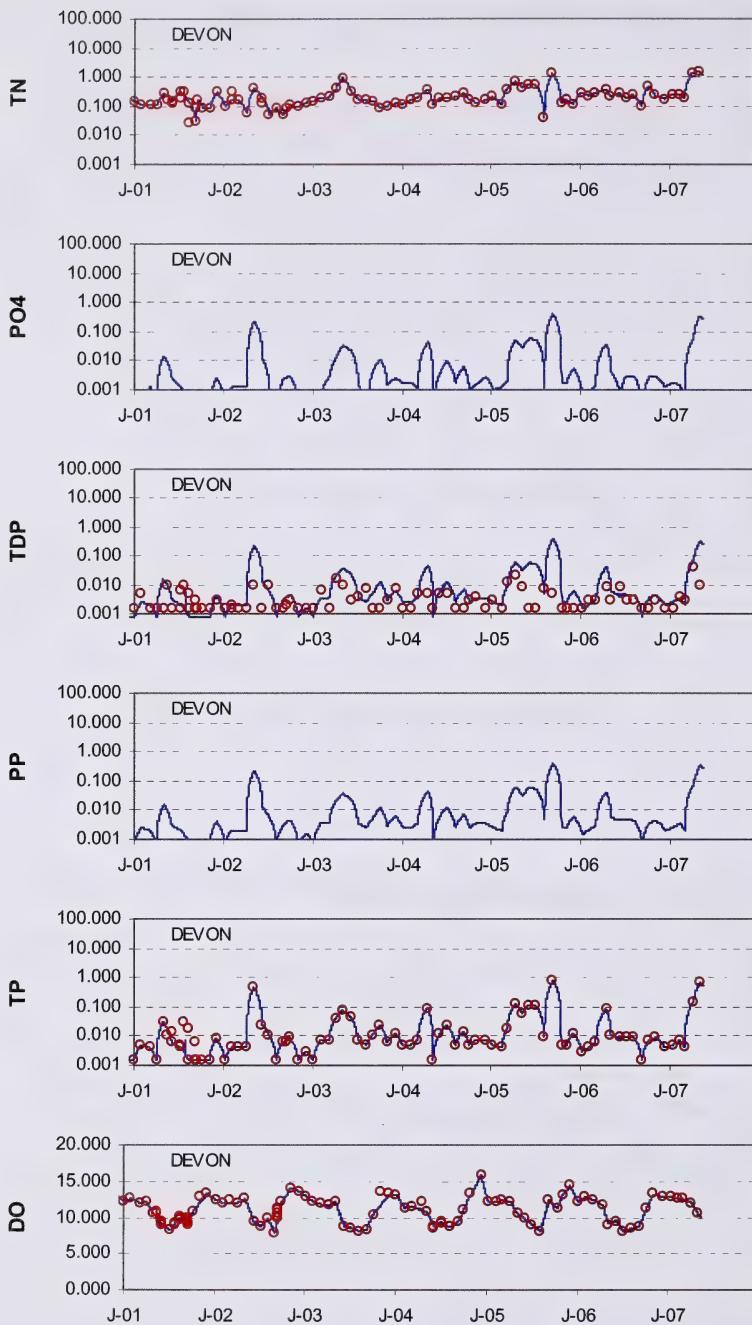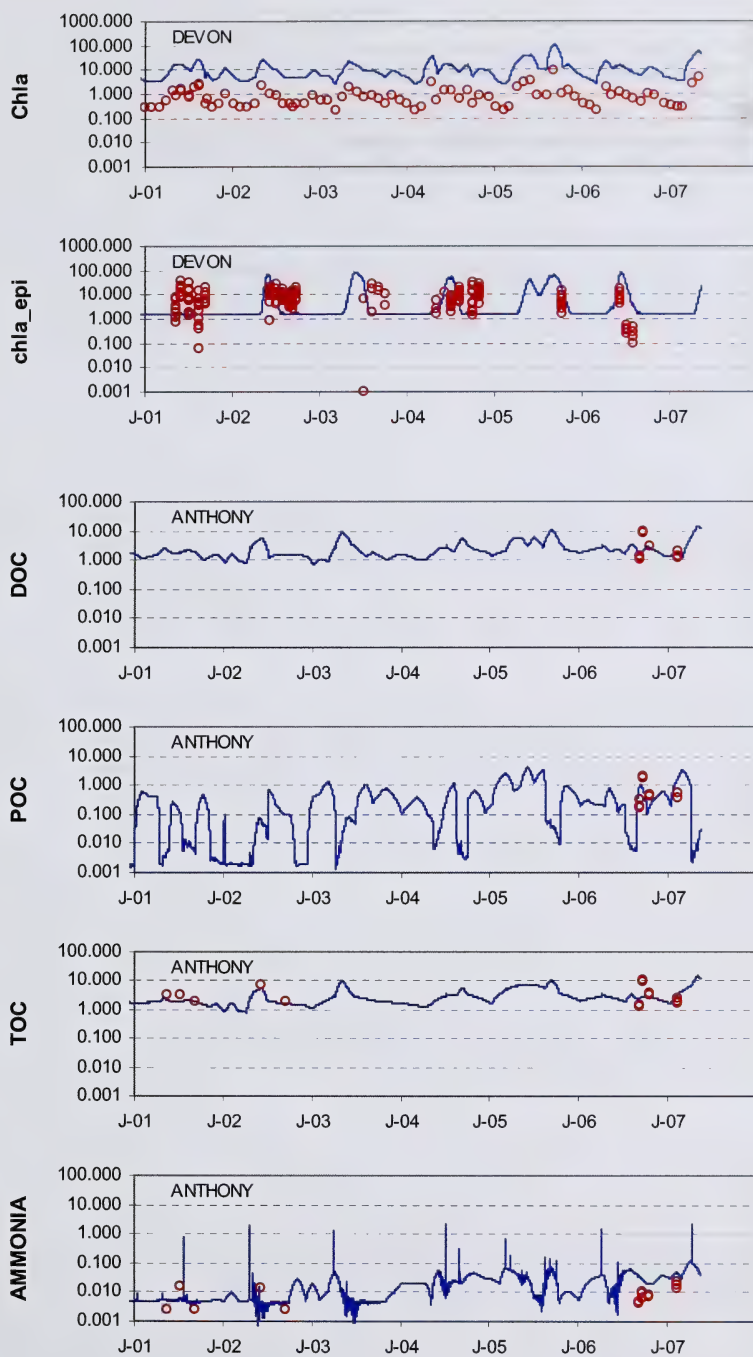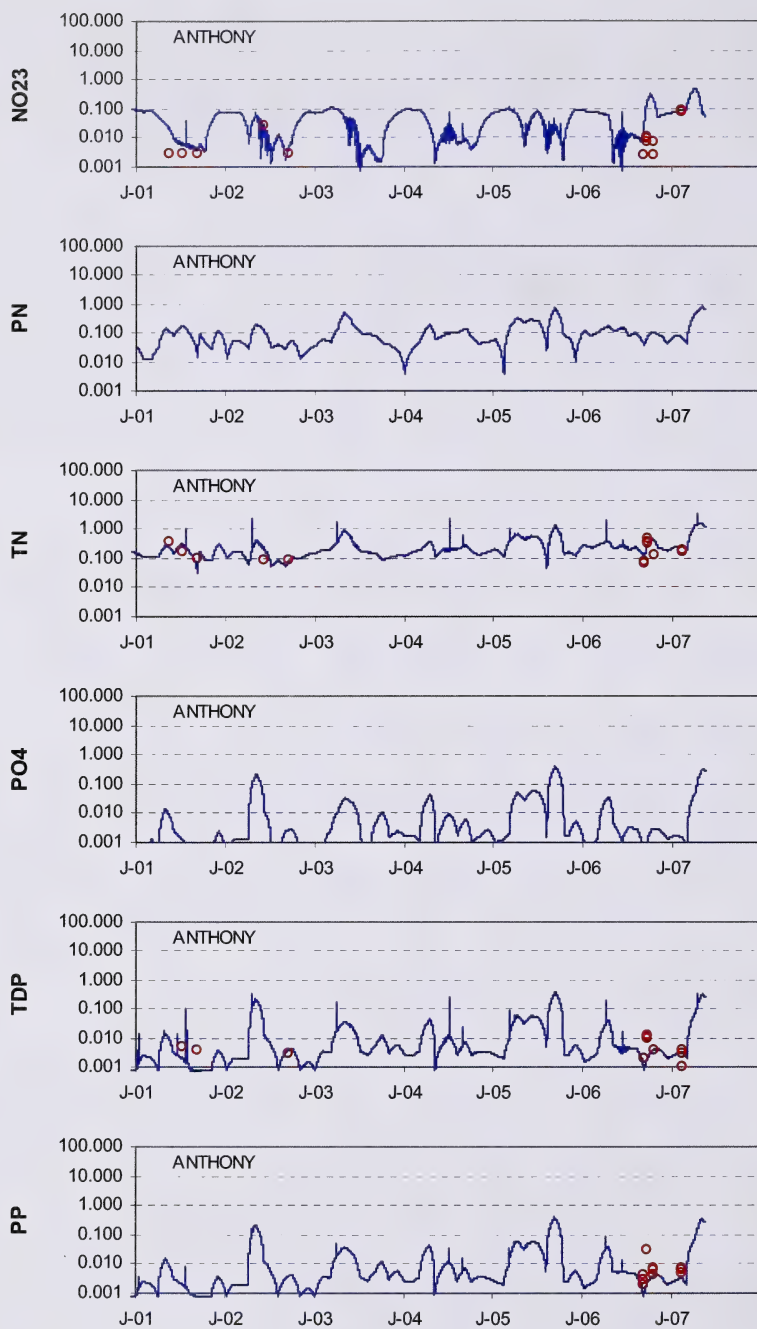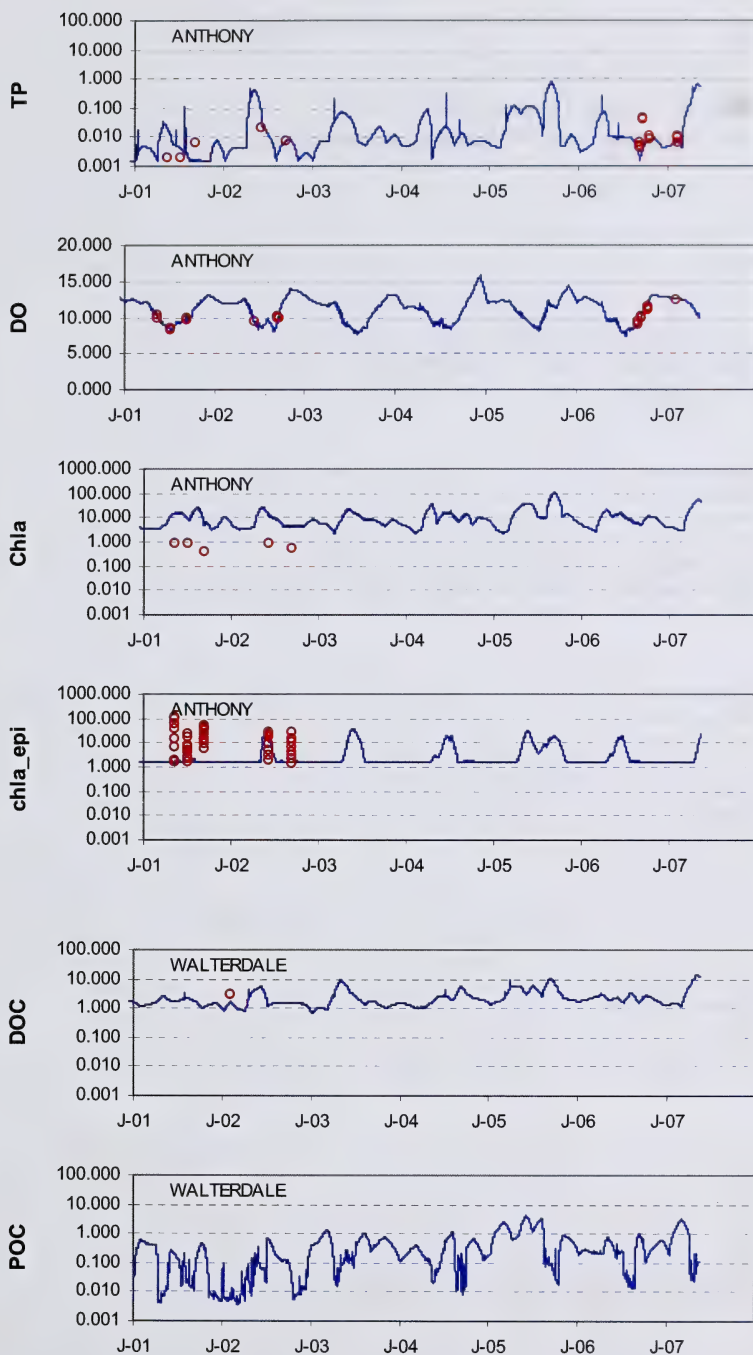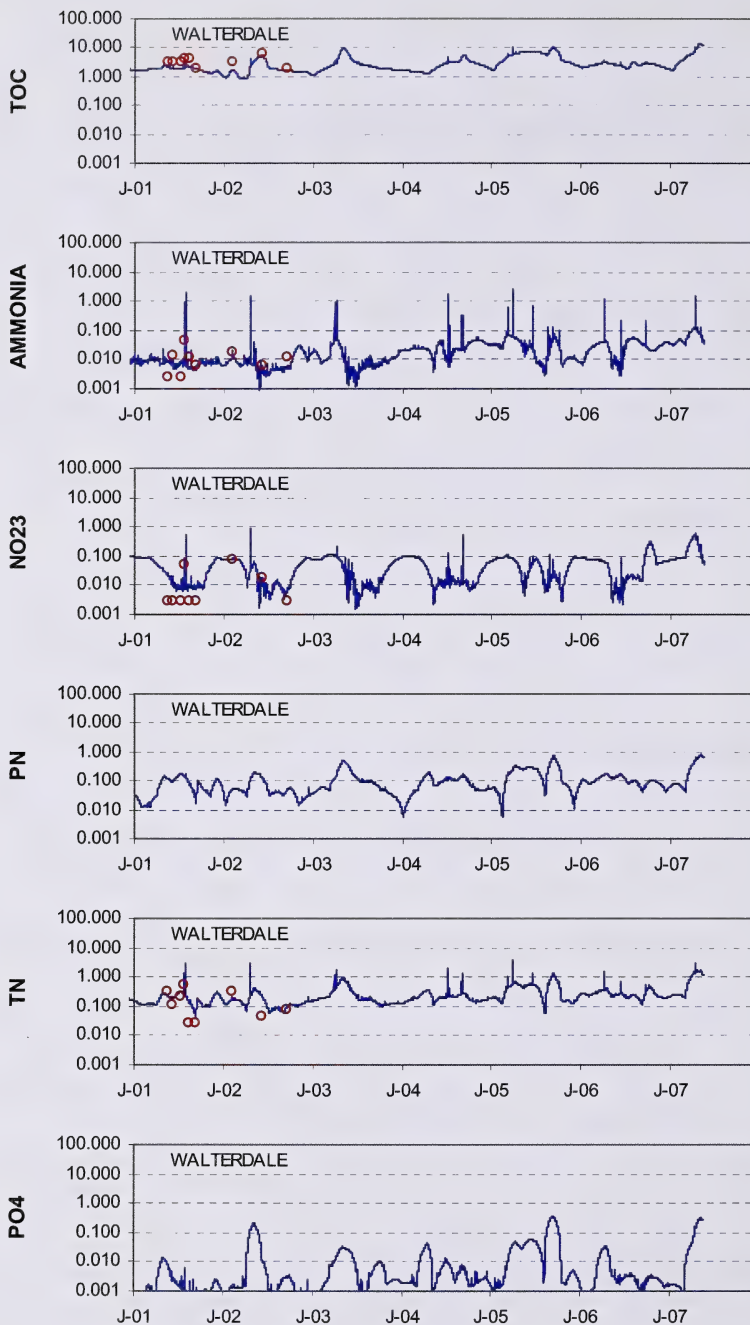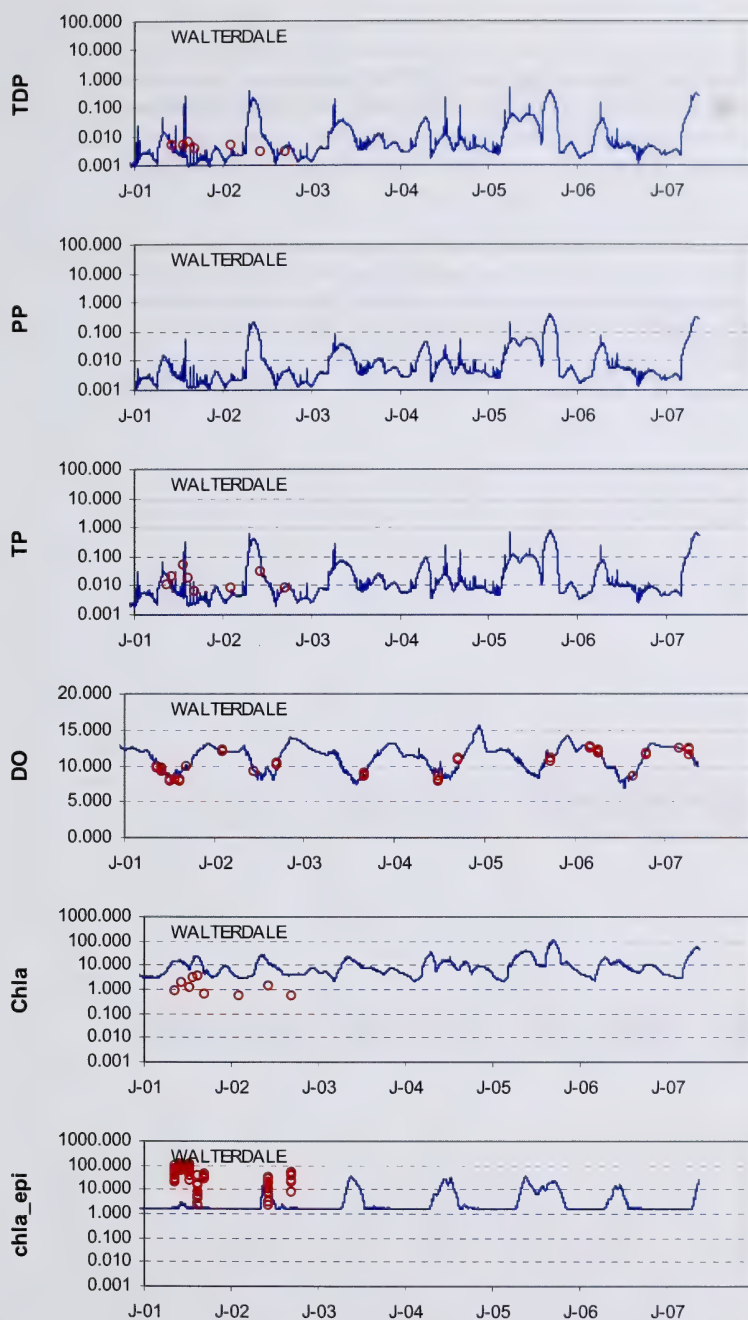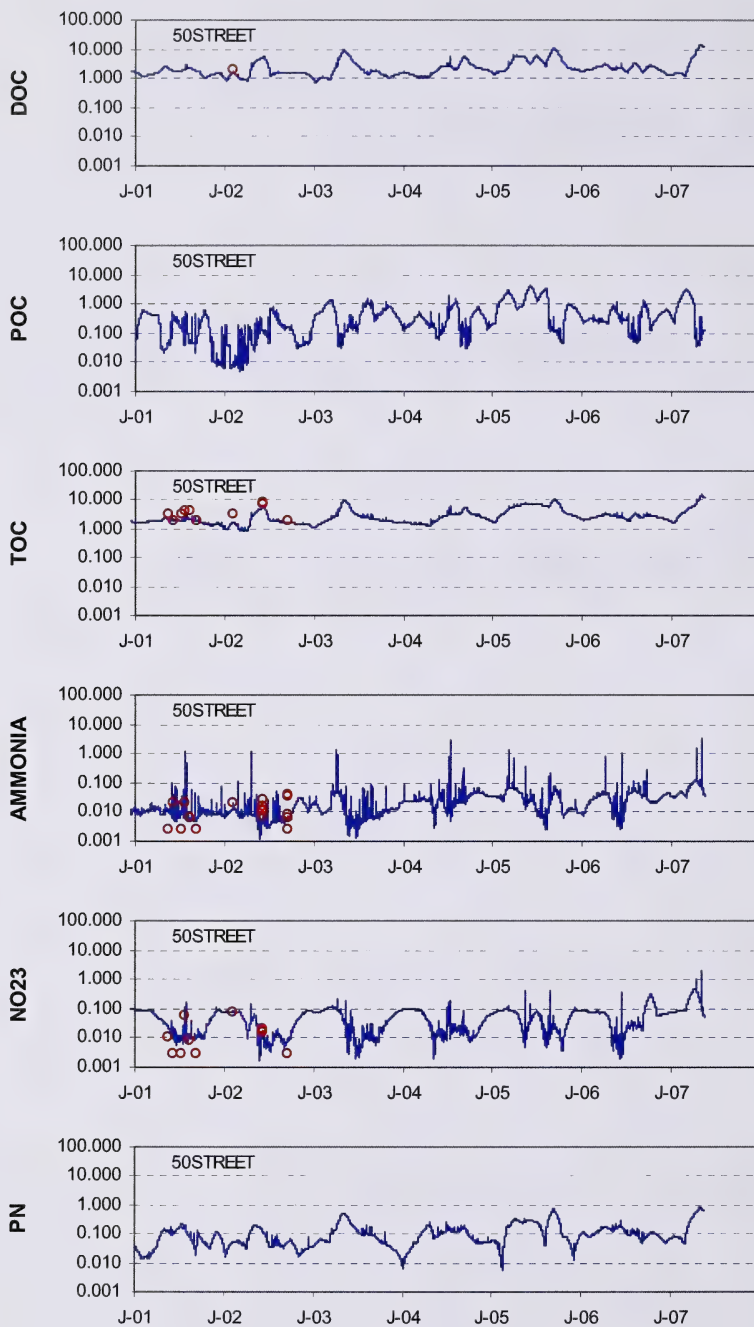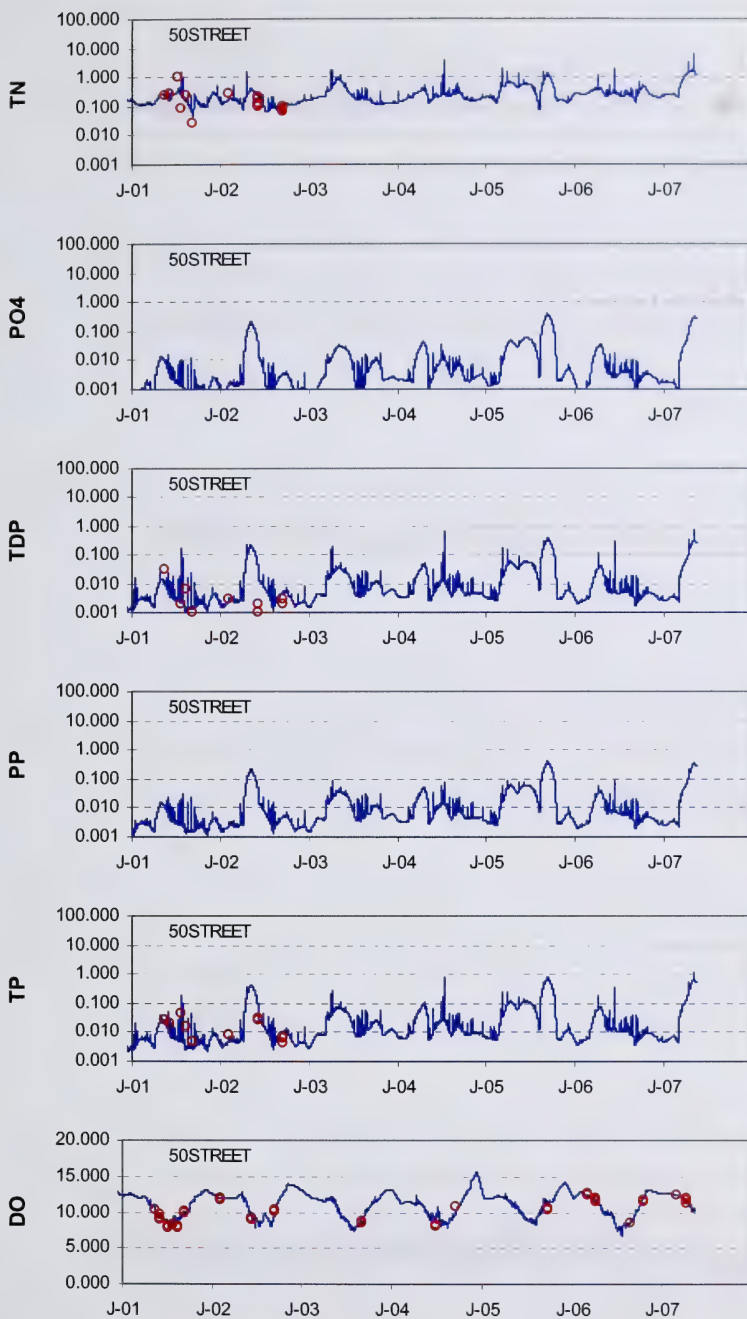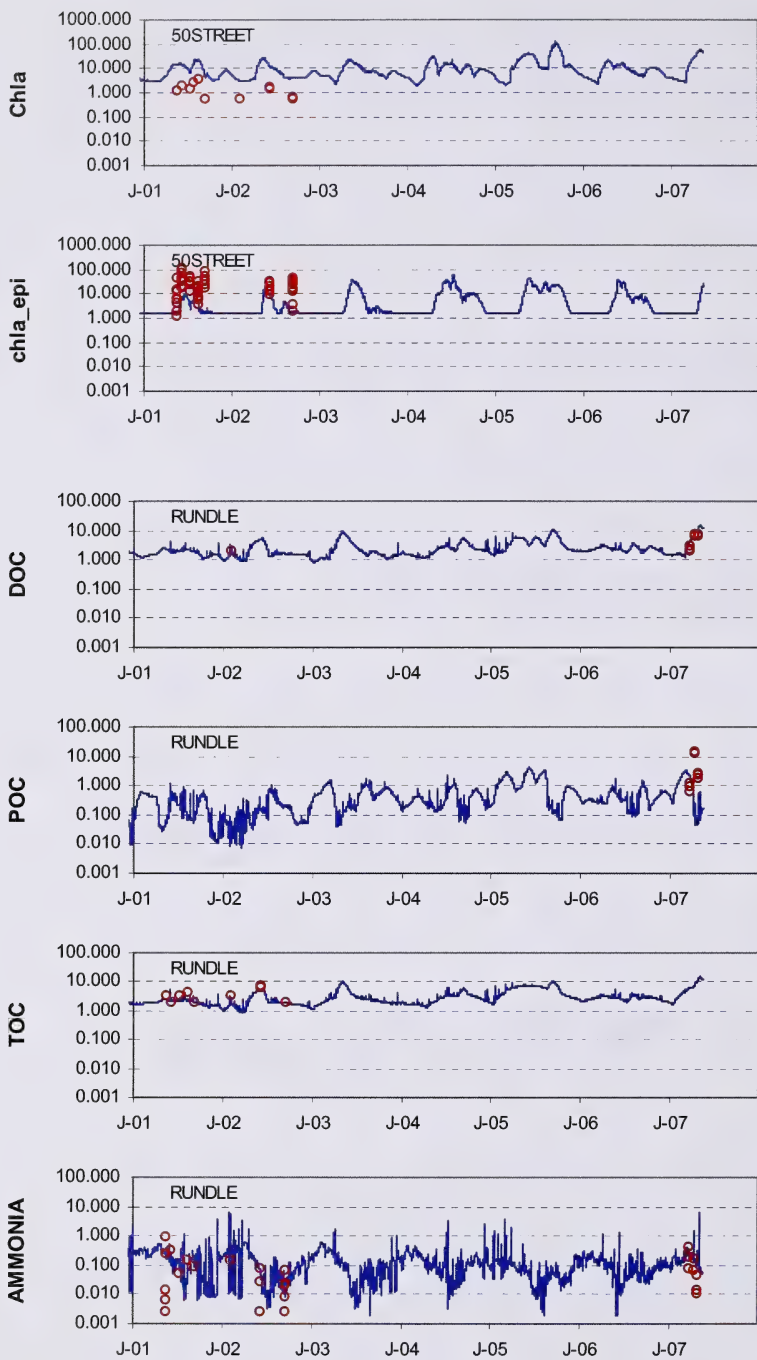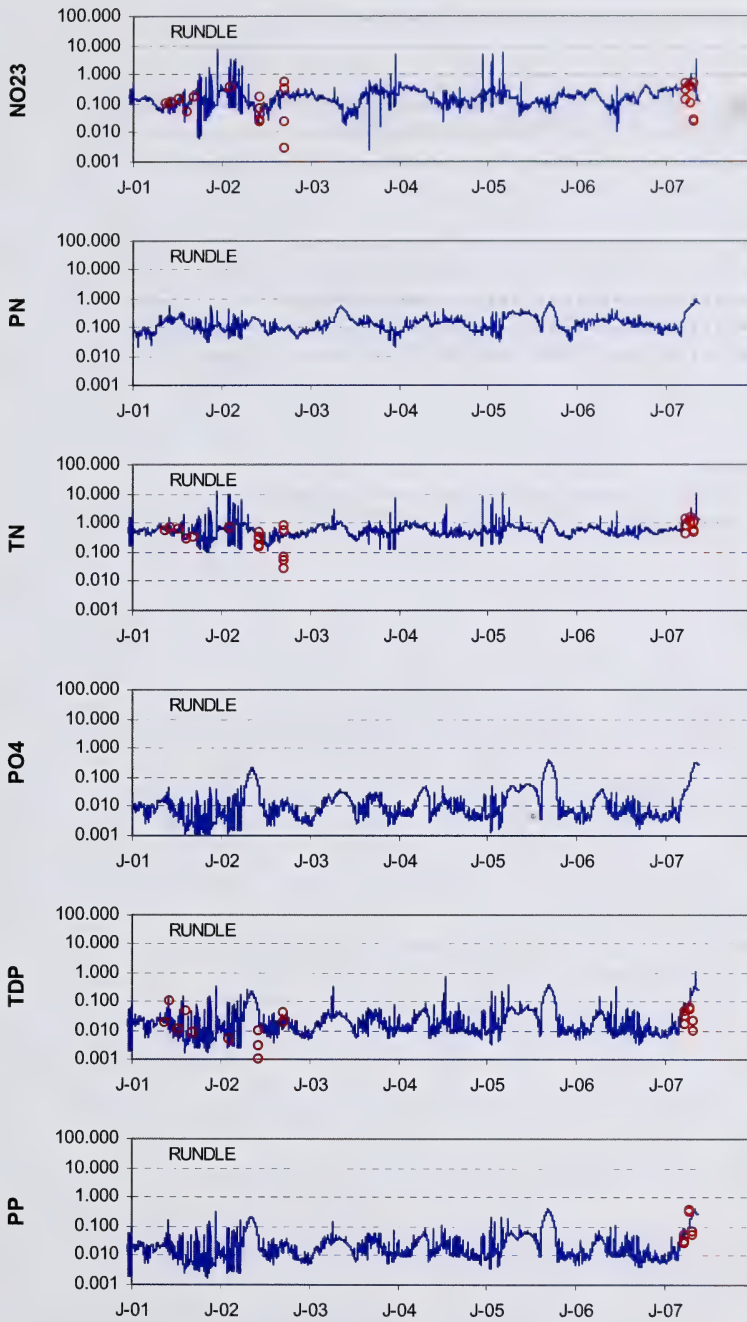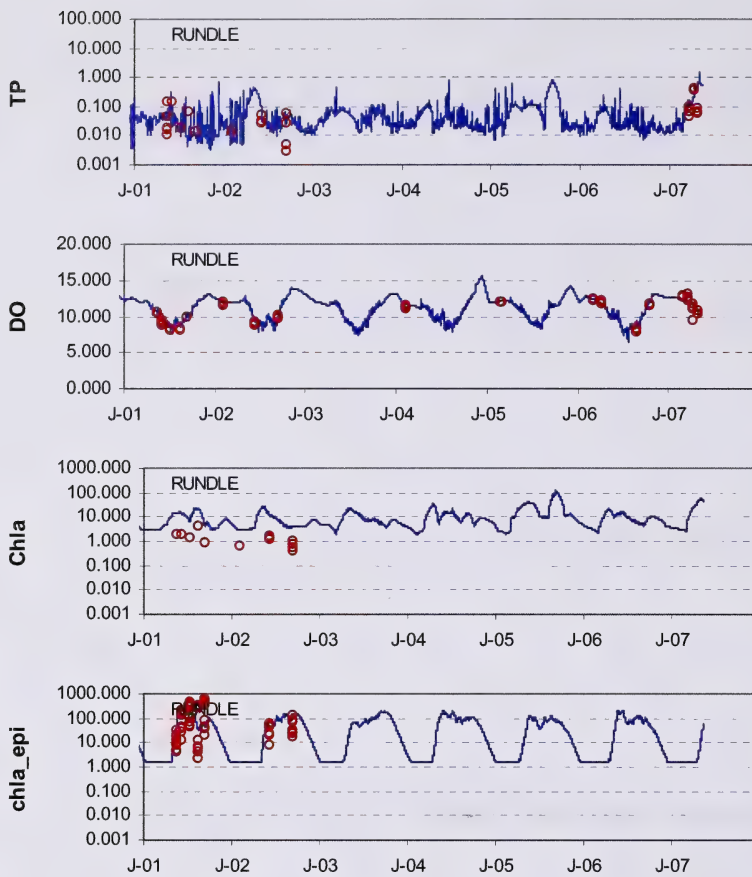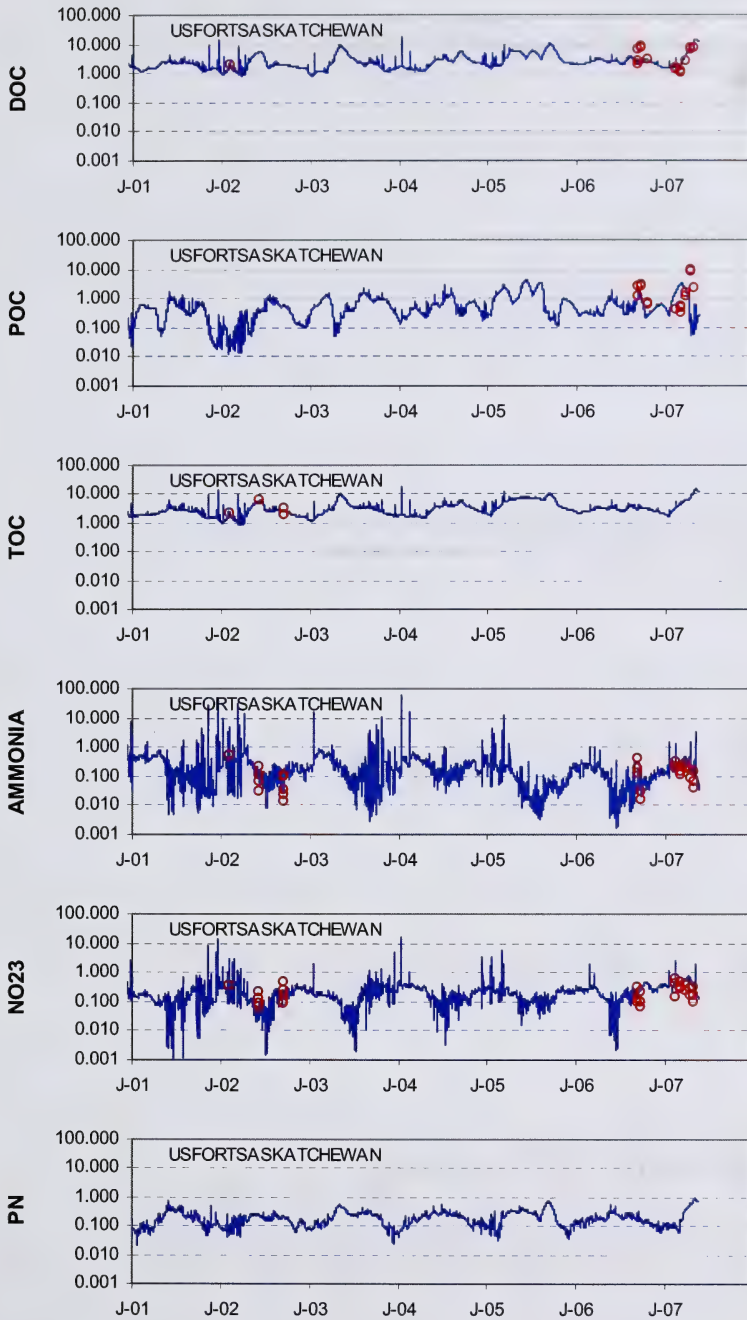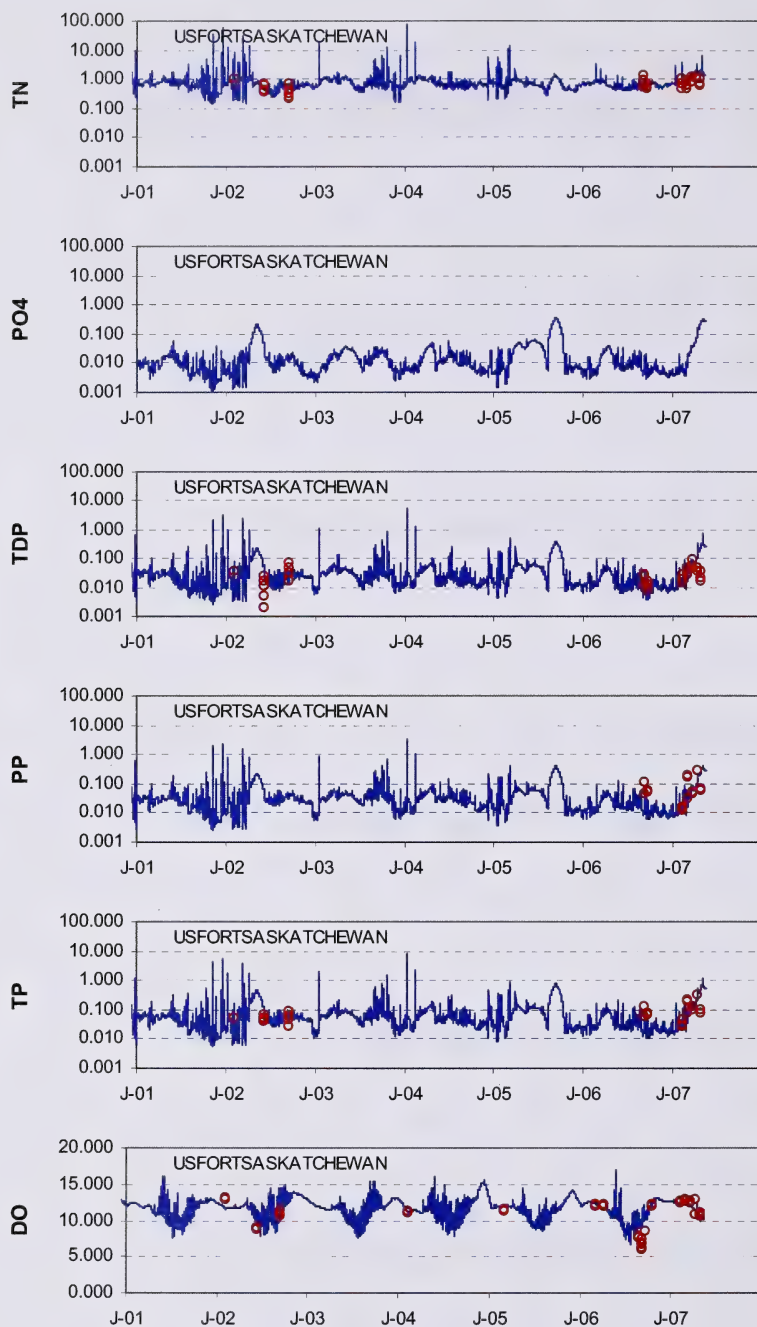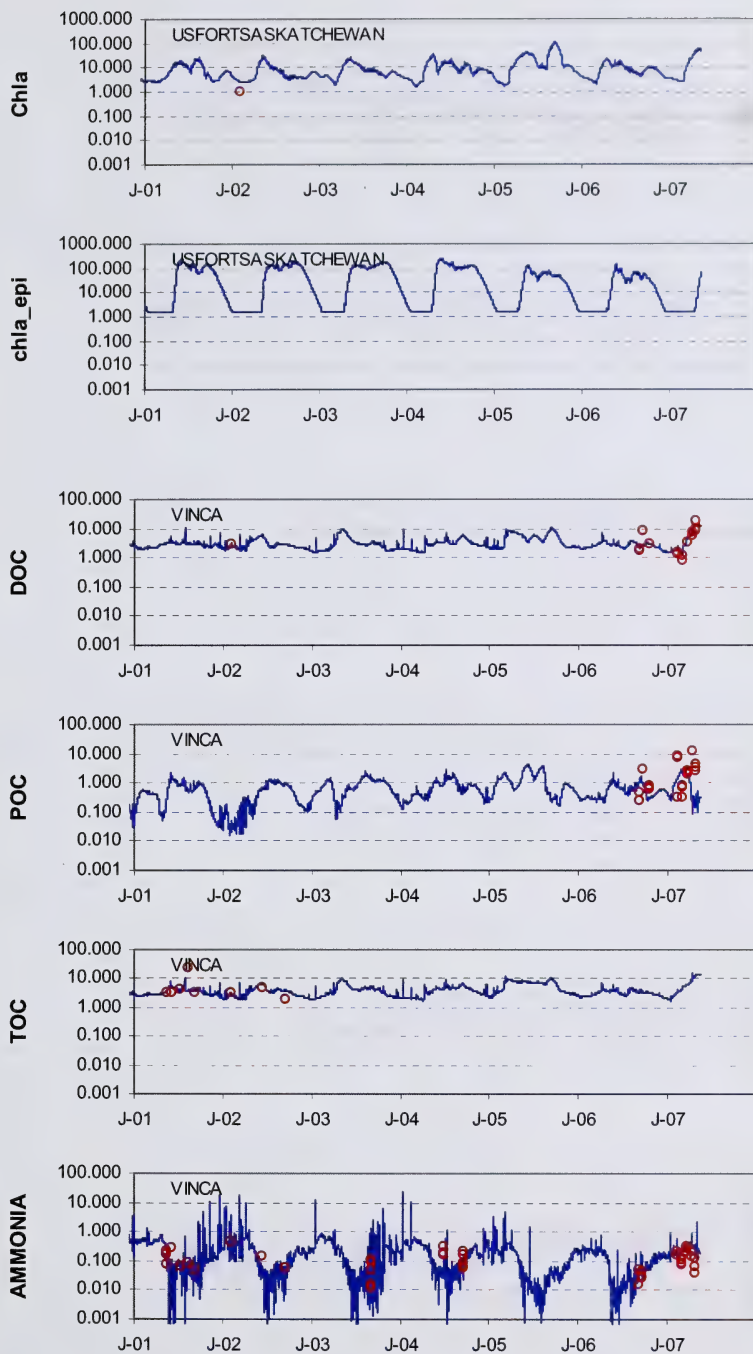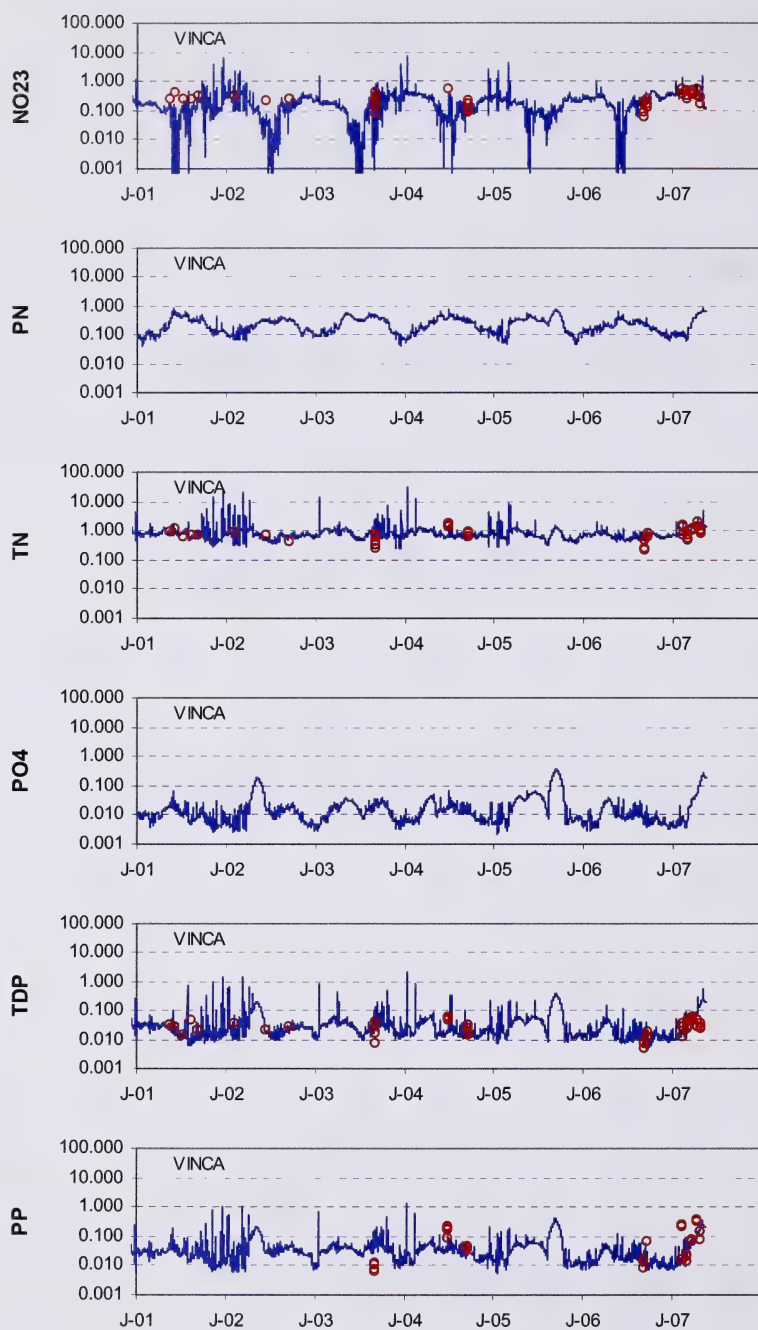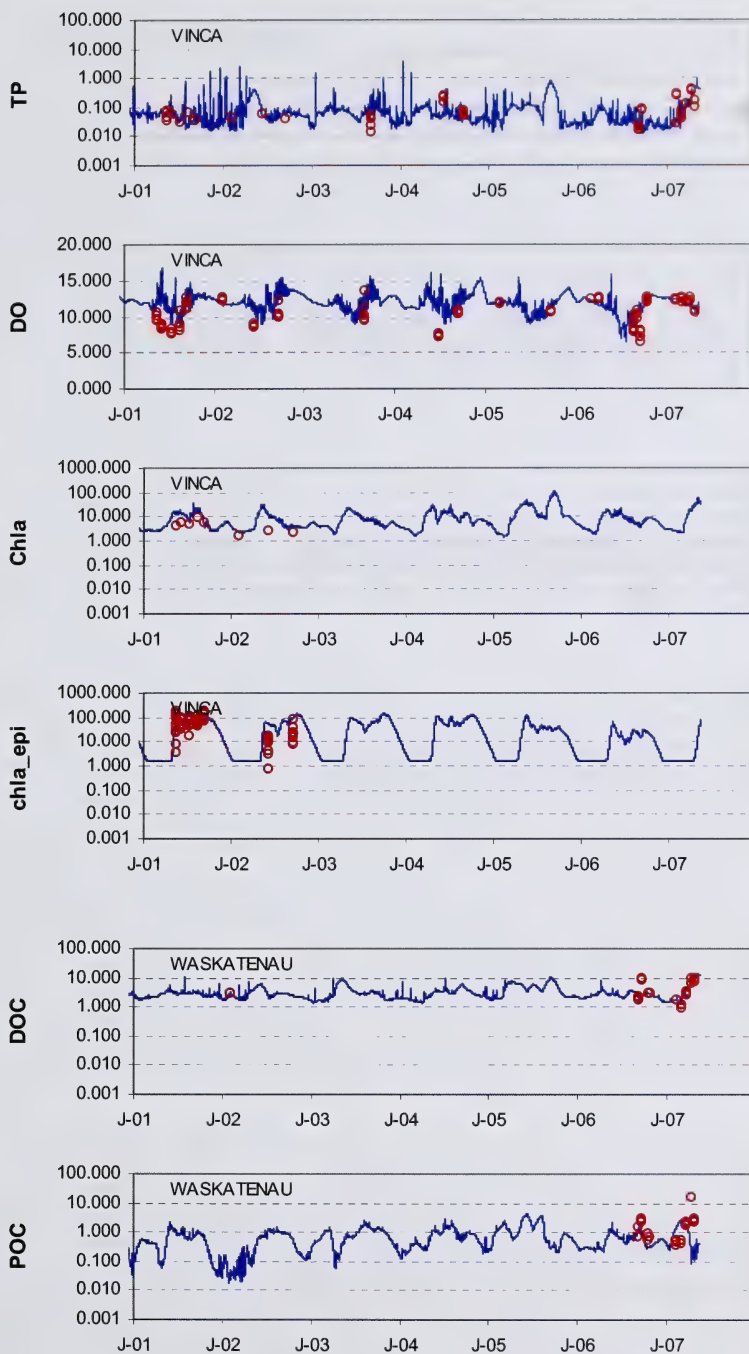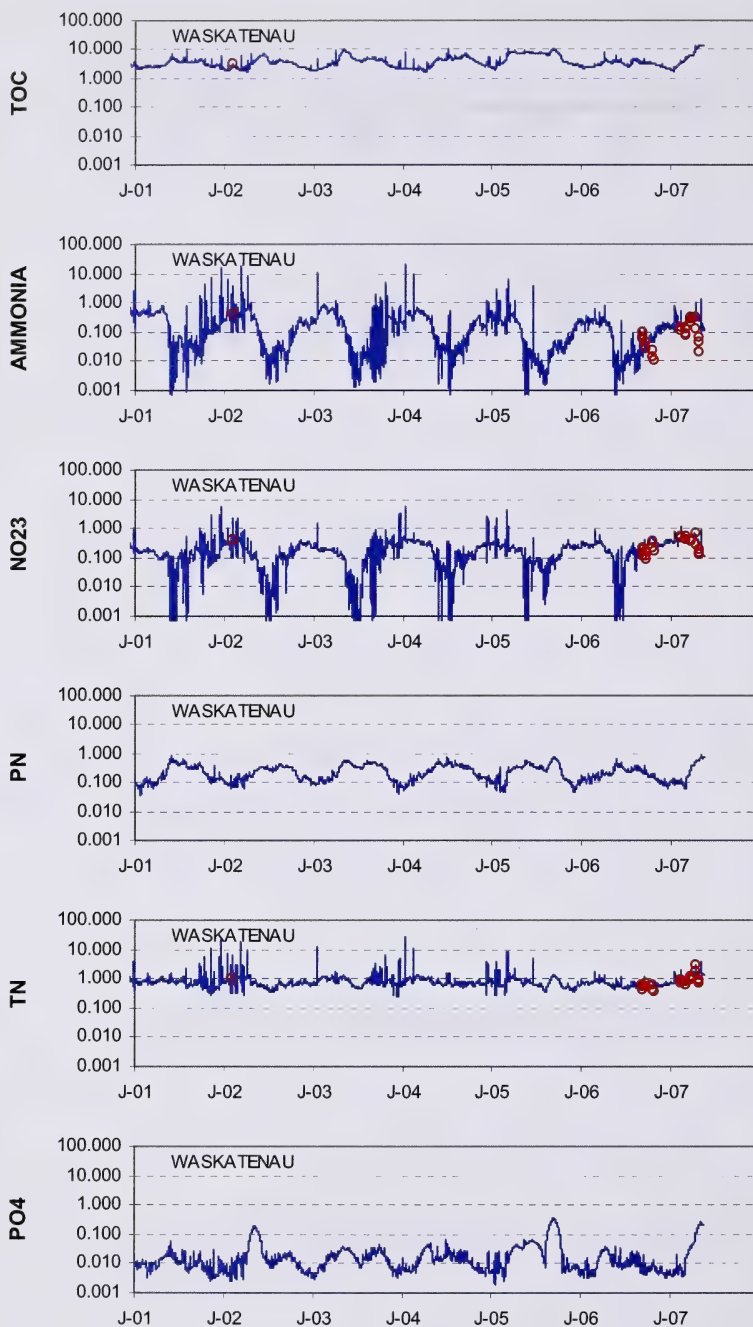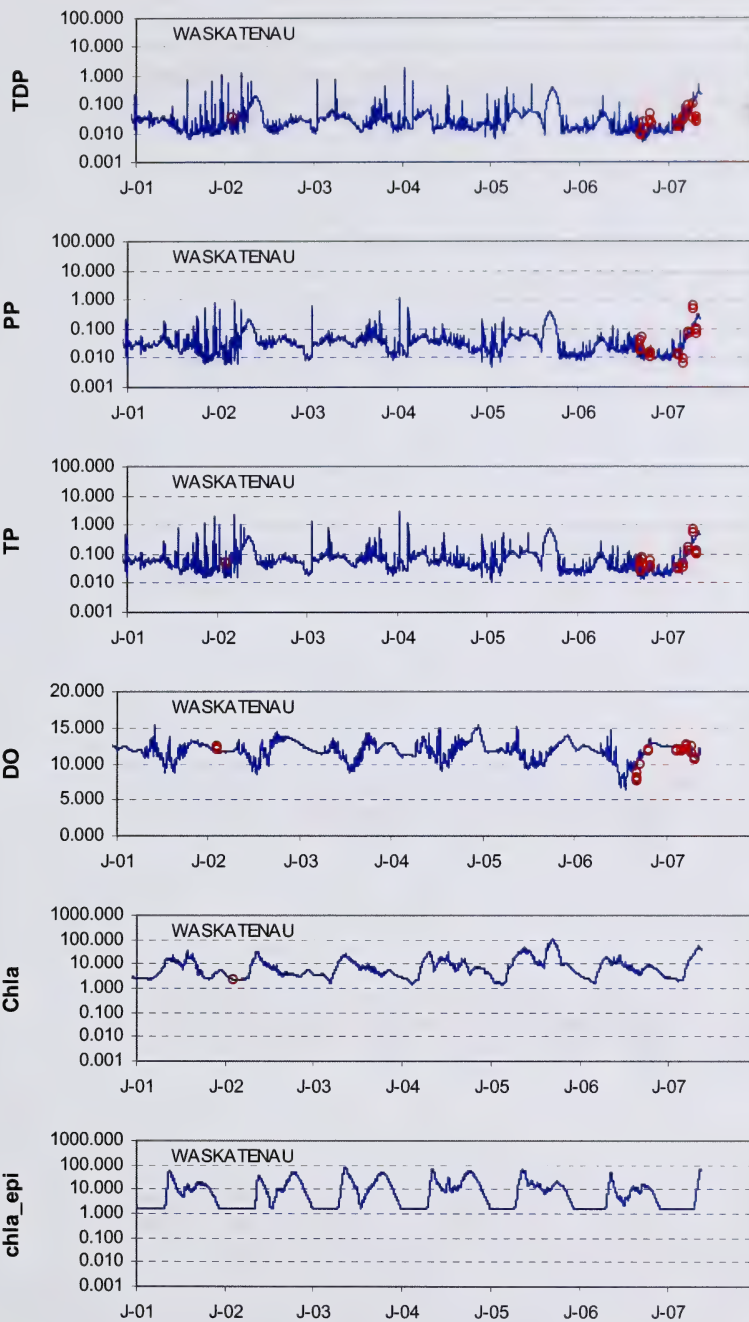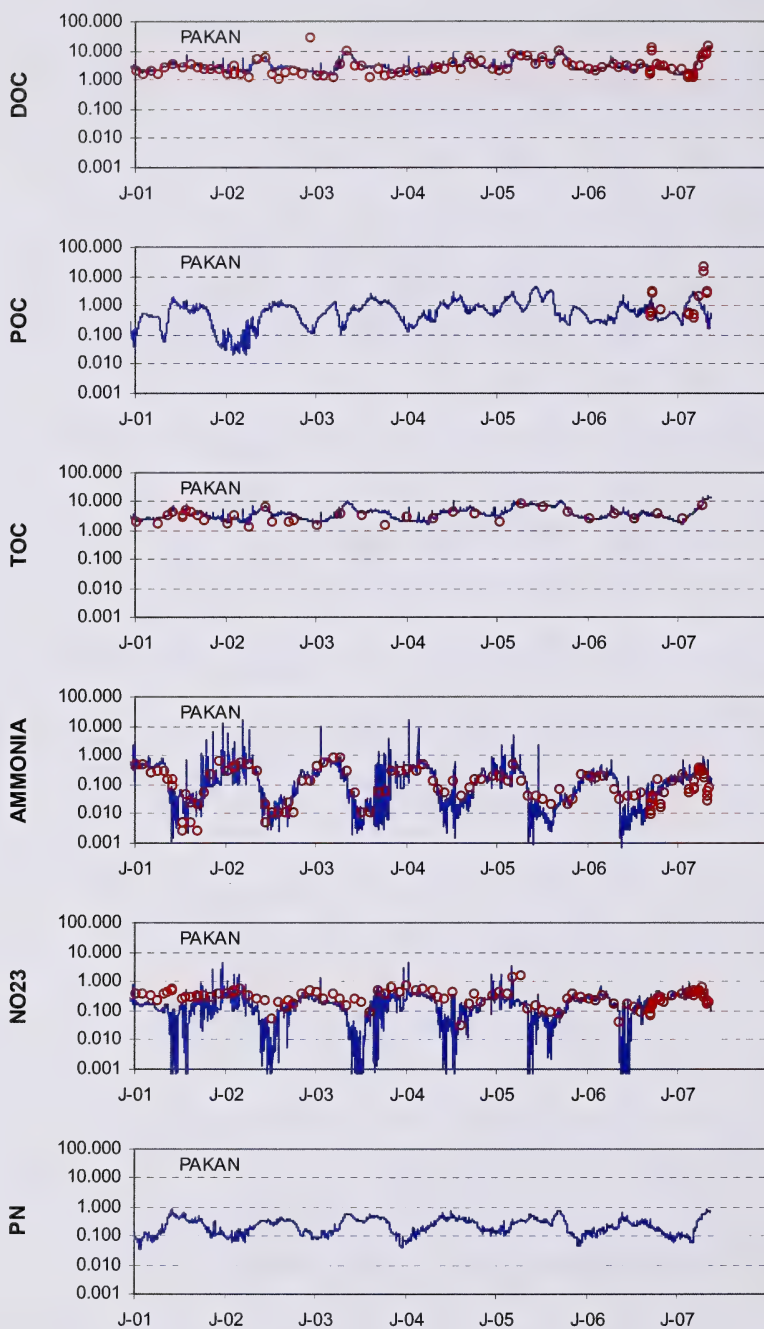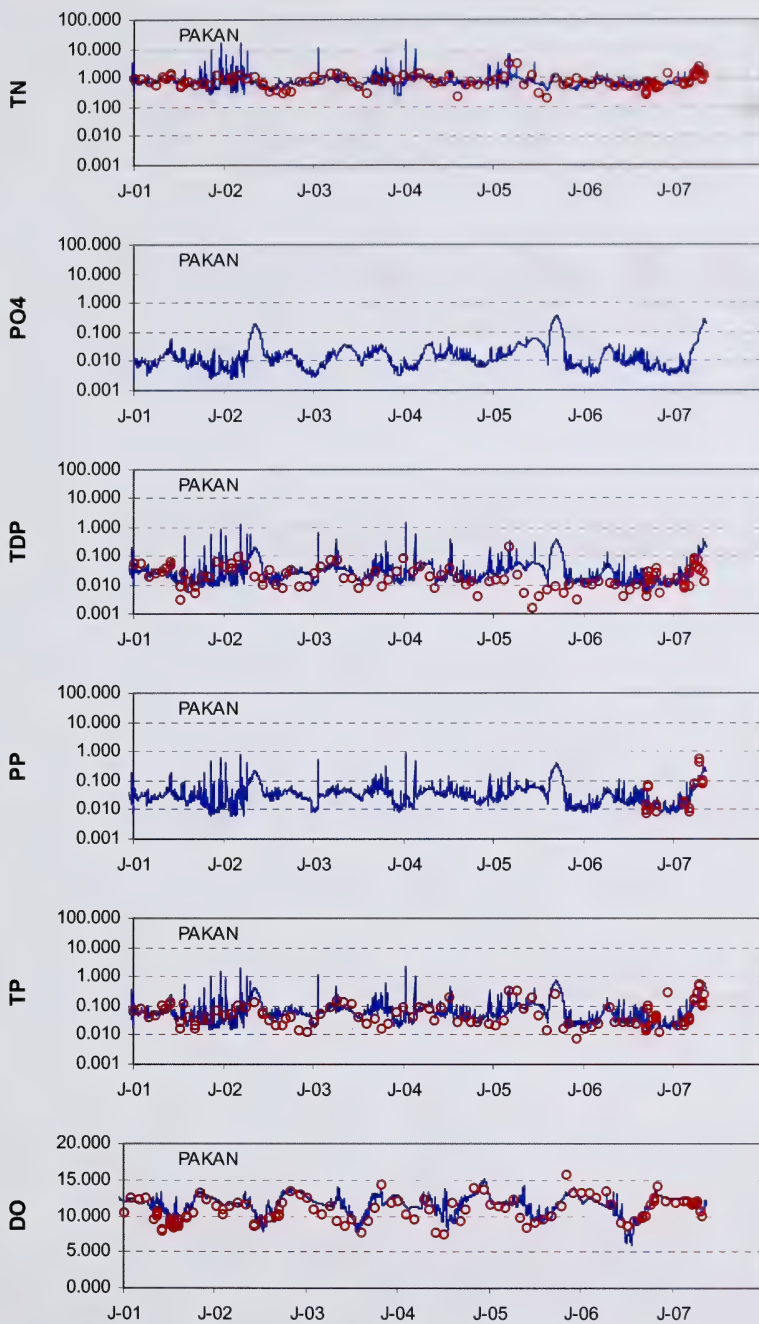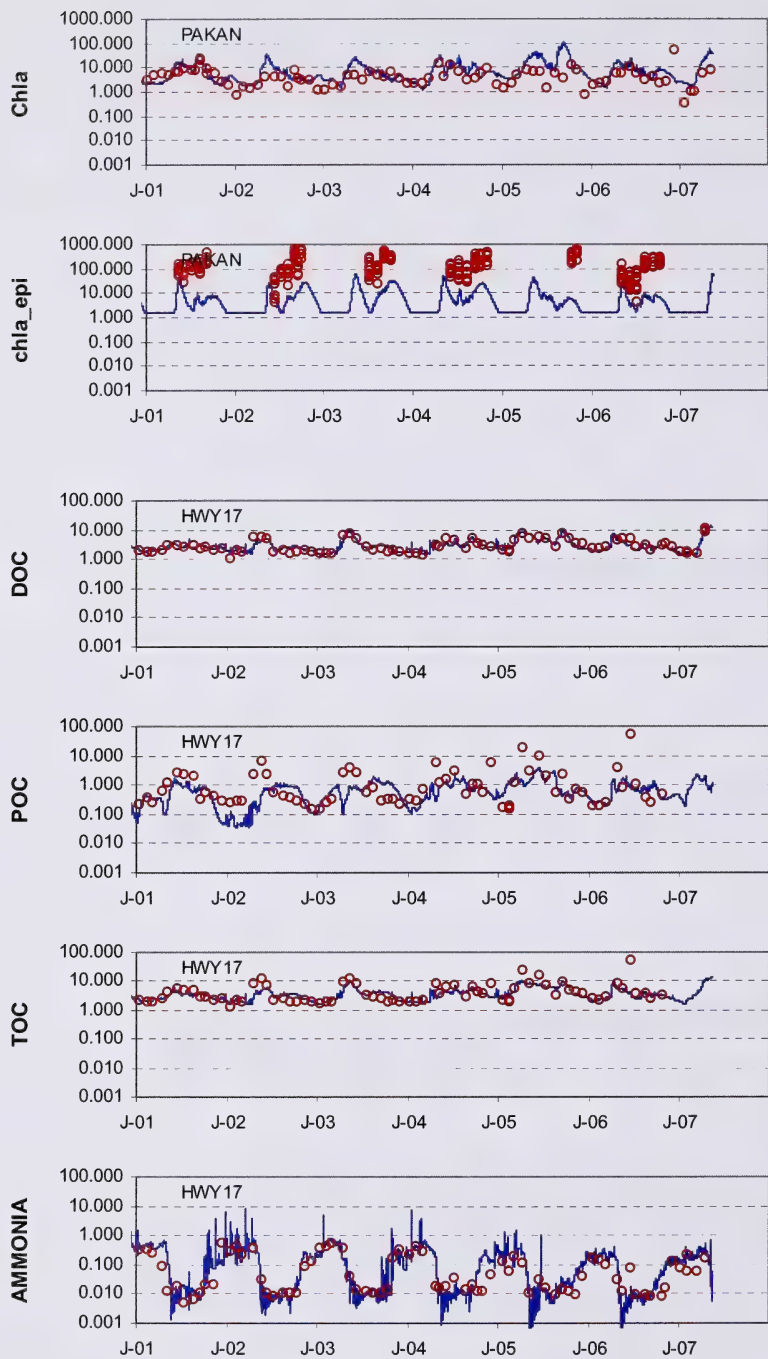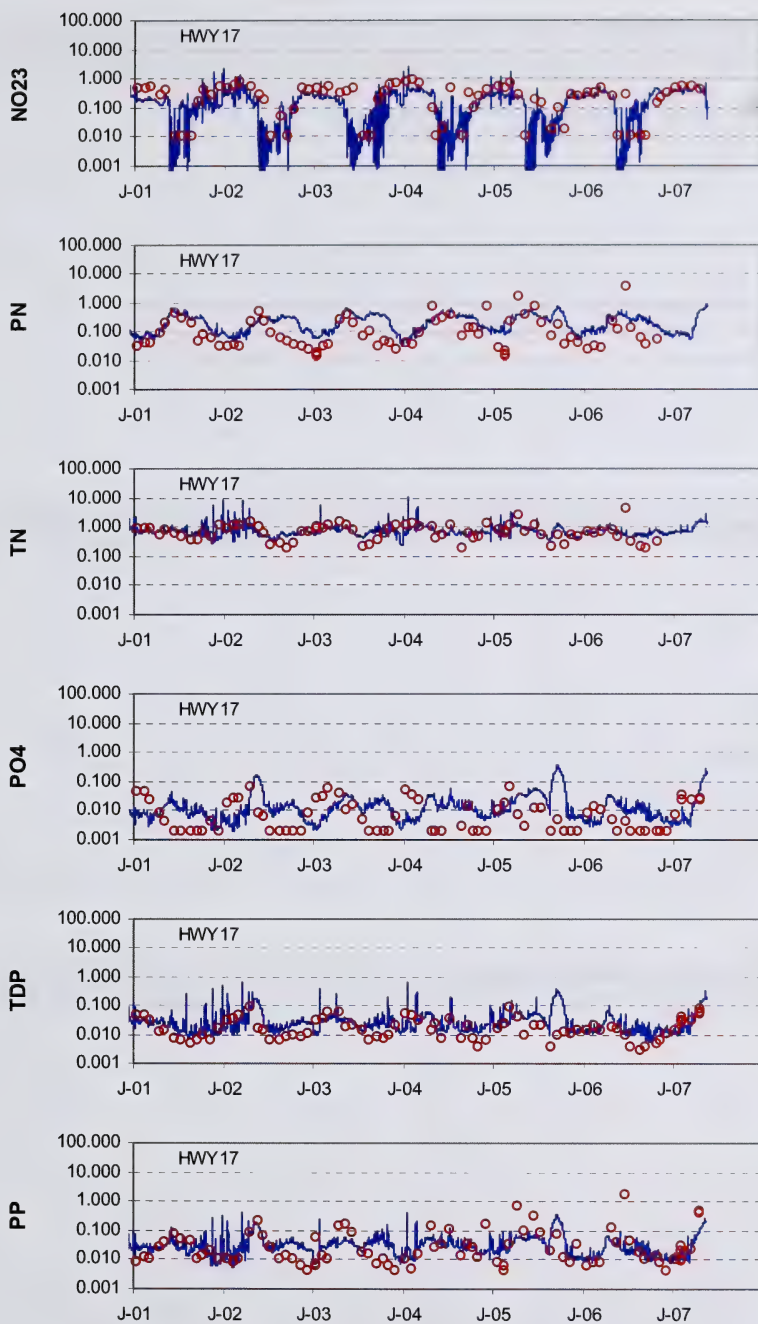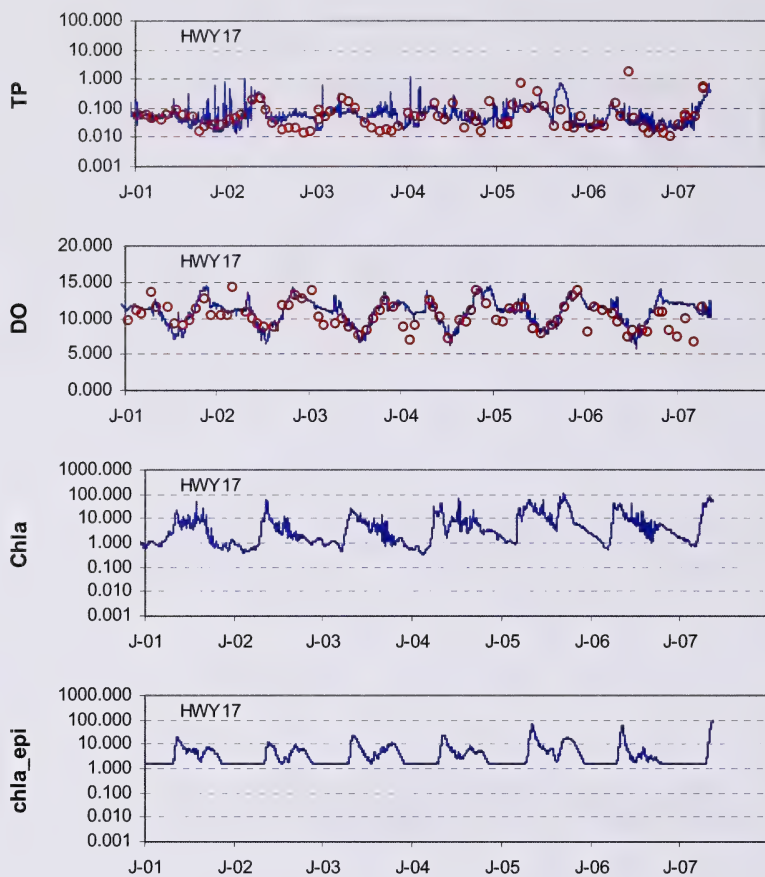
Error Measures for Devon

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	2.506	-0.012	-0.005	0.023	0.009	0.052
POC	-	-	-	-	-	-
TOC	2.749	-0.266	-0.097	0.273	0.099	0.663
AMMONIA	0.020	-0.001	-0.029	0.001	0.048	0.002
NO23	0.048	0.000	0.003	0.001	0.022	0.002
PN	-	-	-	-	-	-
TN	0.242	0.000	0.000	0.009	0.038	0.028
PO4	-	-	-	-	-	-
TDP	0.004	0.014	3.526	0.015	3.787	0.058
PP	-	-	-	-	-	-
TP	0.037	-0.001	-0.018	0.001	0.039	0.004
DO	10.609	-0.107	-0.010	0.151	0.014	0.328
Chla	0.976	10.879	11.220	10.879	11.145	17.184
Chla_epi	7.035	4.534	0.644	13.332	1.895	20.472

Error Measures for Anthony Henday

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	3.550	-1.577	-0.570	1.847	0.520	3.207
POC	0.722	0.159	5.153	0.893	1.238	0.987
TOC	3.792	-1.001	-1.400	2.107	0.556	3.332
AMMONIA	0.009	0.016	1.142	0.018	2.008	0.021
NO23	0.020	0.063	1.940	0.064	3.240	0.100
PN						
TN	0.179	0.054	0.291	0.104	0.579	0.130
PO4						
TDP	0.004	-0.001	-0.276	0.004	0.851	0.005
PP	0.012	-0.009	-15.242	0.009	0.773	0.015
TP	0.014	-0.007	-0.839	0.010	0.707	0.017
DO	10.039	0.105	0.039	0.298	0.030	0.430
Chla	0.700	7.805	5.825	7.805	11.150	8.690
Chla_epi	19.465	-15.396	-0.791	17.006	0.874	29.699

Error Measures for 50 Street

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	3.000	-1.330	-0.001	1.330	0.443	1.330
POC						
TOC	3.333	-0.994	-0.005	0.994	0.298	1.147
AMMONIA	0.013	-0.005	-0.001	0.008	0.602	0.012
NO23	0.018	0.001	0.000	0.011	0.607	1.221
PN						
TN	0.187	-0.005	0.000	0.108	0.579	0.131
PO4						
TDP	0.004	0.001	0.001	0.004	1.099	0.005
PP						
TP	0.017	-0.008	-0.001	0.011	0.662	0.017
DO	10.030	0.183	0.002	0.448	0.045	0.574
Chla	1.467	9.289	0.067	9.289	6.333	10.812
Chla_epi	39.538	-36.300	-0.918	37.194	0.941	46.771

Error Measures for Rundle

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	5.100	2.469	0.015	2.533	0.497	3.307
POC	5.316	-4.667	-0.067	5.315	1.000	7.593
TOC	3.625	-0.546	-0.005	0.563	0.155	0.740
AMMONIA	0.113	0.016	0.008	0.095	0.842	0.158
NO23	0.165	0.080	0.014	0.154	0.935	0.648
PN						
TN	0.566	0.242	0.017	0.344	0.608	0.471
PO4						
TDP	0.023	0.044	0.082	0.057	2.470	0.099
PP	0.143	0.018	0.007	0.152	1.064	0.173
TP	0.079	0.045	0.030	0.090	1.136	0.163
DO	10.520	0.179	0.002	0.410	0.039	0.513
Chla	1.288	7.224	0.099	7.224	5.611	8.494
Chla_epi	121.787	-20.084	-0.165	121.283	0.996	182.793

Error Measures for NSR Upstream of Fort Saskatchewan

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	4.109	-0.047	-0.001	1.966	0.478	2.870
POC	2.157	-1.002	-0.033	2.168	1.005	3.266
TOC	3.918	0.142	0.001	0.296	0.075	0.397
AMMONIA	0.142	-0.008	-0.004	0.083	0.588	0.135
NO23	0.226	0.063	0.013	0.133	0.589	0.618
PN						
TN	0.684	0.156	0.013	0.331	0.483	0.435
PO4						
TDP	0.028	0.028	0.060	0.040	1.408	0.083
PP	0.089	-0.010	-0.008	0.085	0.948	0.112
TP	0.094	0.023	0.014	0.081	0.857	0.155
DO	10.739	0.709	0.006	1.089	0.101	1.501
Chla	1.000	1.420	0.001	1.420	1.420	1.420
Chla_epi						

Error Measures for Vinca

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	4.504	-0.062	-0.001	1.816	0.403	2.661
POC	3.041	-1.868	-0.057	2.901	0.954	4.318
TOC	5.625	-1.309	-0.005	3.284	0.584	6.523
AMMONIA	0.132	0.002	0.001	0.092	0.696	0.123
NO23	0.294	-0.062	-0.016	0.130	0.442	0.534
PN						
TN	0.859	0.051	0.005	0.290	0.338	0.360
PO4						
TDP	0.029	0.015	0.043	0.025	0.837	0.049
PP	0.087	-0.025	-0.031	0.059	0.682	0.091
TP	0.100	0.001	0.000	0.060	0.606	0.097
DO	10.425	1.218	0.014	1.540	0.148	2.196
Chla	4.450	5.065	0.033	5.411	1.216	6.947
Chla_epi	60.134	16.521	0.275	43.006	0.715	50.870

Error Measures for Waskatenau

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	4.275	0.059	0.001	1.809	0.423	2.866
POC	2.657	-1.491	-0.042	2.548	0.959	4.916
TOC	3.000	-0.354	0.000	0.354	0.118	0.354
AMMONIA	0.116	0.056	0.018	0.101	0.868	0.129
NO23	0.310	0.043	0.006	0.128	0.414	0.748
PN						
TN	0.846	0.123	0.007	0.325	0.384	0.470
PO4						
TDP	0.033	0.026	0.038	0.036	1.098	0.070
PP	0.080	-0.018	-0.014	0.065	0.813	0.132
TP	0.110	0.008	0.003	0.087	0.790	0.158
DO	11.021	0.450	0.002	0.782	0.071	1.018
Chla	2.200	-0.132	0.000	0.132	0.060	0.132
Chla_epi						

Error Measures for Pakan

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	3.524	0.047	0.003	1.142	0.324	2.976
POC	2.774	-1.513	-0.060	2.728	0.983	5.122
TOC	3.244	0.769	0.017	0.899	0.277	1.099
AMMONIA	0.151	0.060	0.118	0.117	0.773	0.397
NO23	0.314	-0.087	-0.072	0.151	0.482	0.196
PN						
TN	0.787	0.075	0.025	0.291	0.370	0.562
PO4						
TDP	0.025	0.018	0.163	0.030	1.208	0.065
PP	0.076	-0.019	-0.021	0.059	0.781	0.116
TP	0.074	0.016	0.043	0.056	0.754	0.111
DO	10.500	0.821	0.023	1.145	0.109	1.465
Chla	5.487	3.486	0.279	5.944	1.083	14.089
Chla_epi	179.901	-169.832	-0.944	169.896	0.944	225.897

Error Measures for HW17

WQ Variables	Mean of Observations	Mean Error	Relative Mean Error	Mean Absolute Error	Relative Mean Absolute Error	Root Mean Square Error
DOC	3.122	0.034	0.003	0.574	0.184	0.779
POC	1.874	-1.187	-0.205	1.582	0.844	5.772
TOC	4.793	-1.114	-0.064	1.878	0.392	6.045
AMMONIA	0.120	0.050	0.125	0.094	0.782	0.136
NO23	0.328	-0.127	-0.127	0.165	0.503	0.000
PN	0.186	0.041	0.068	0.194	1.039	0.420
TN	0.774	-0.068	-0.025	0.302	0.390	0.516
PO4	0.014	0.008	0.119	0.022	1.620	0.041
TDP	0.023	0.012	0.121	0.020	0.882	0.041
PP	0.076	-0.038	-0.192	0.064	0.844	0.200
TP	0.099	-0.026	-0.076	0.068	0.688	0.198
DO	10.320	0.735	0.015	1.277	0.124	1.689
Chla						
Chla_epi						

Appendix G. EFDC Control File (Text)

```
C1  TITLE FOR RUN
C
    TITLE OR IDENTIFIER FOR THIS INPUT FILE AND RUN
C
C1  (LIMIT TO 80 CHARACTERS LENGTH)
   'North Saskatchewan River 2D_1D model'
-------------------------------------------------------------------------------
C1A  GRID CONFIGURATION AND TIME INTEGRATION MODE SELECTION
C
       IGRIDH: 0 SINGLE HORIZONTAL GRID WITHOUT HORIZONTAL PARALLELIZATION
             1 SINGLE HORIZONTAL GRID WITH HORIZONTAL PARALLELIZATION
              GE.2, NUMBER OF HORIZONTAL GRIDS WITH HORIZONTAL DOMAIN
              DECOMPOSITION PARALLELIZATION
             -1 ONE DIMENSIONAL CHANNEL NETWORK WITH HEC TYPE CROSS SECTIONS
       INESTH:  1 NO NESTING FOR IGRIDH.GE.2
              2 2 TO 1 NESTING (FINE TO COARSE) FOR IGRIDH.GE.2
              3 3 TO 1 NESTING (FINE TO COARSE) FOR IGRIDH.GE.2
       IGRIDV:  0 STANDARD SIGMA VERTICAL GRID OR SINGLE LAYER DEPTH AVERAGE
              1 GENERAL VERTICAL GRID WITH SIGMA AND RESCALED HEIGHT REGIONS
       ITIMSOL:  0 THREE TIME LEVEL INTEGRATION
              1 TWO TIME LEVEL INTEGRATION
  ISHOUSATONIC: 1 ACTIVATE HOUSATONIC RIVER SUPERFUND SEDTOX OPTIONS
C
C1A IGRIDH  INESTH  IGRIDV  ITIMSOL  ISHOUSATONIC
     0    0    0    1    0
-------------------------------------------------------------------------------
C2  RESTART, GENERAL CONTROL AND AND DIAGNOSTIC SWITCHES
C
       ISRESTI: 1 FOR READING INITIAL CONDITIONS FROM FILE  restart.inp
              -1 AS ABOVE BUT ADJUST FOR CHANGING BOTTOM ELEVATION
               2 INTIALIZES A KC LAYER RUN FROM A KC/2 LAYER RUN FOR KC.GE.4
              10 FOR READING IC'S FROM restart.inp WRITTEN BEFORE 8 SEPT 92
       ISRESTO:-1 FOR WRITING RESTART FILE restart.out AT END OF RUN
              N INTEGER.GE.0 FOR WRITING restart.out EVERY N REF TIME PERIODS
       ISRESTR: 1 FOR WRITING RESIDUAL TRANSPORT FILE restran.out
       ISLOG:   1 FOR WRITING LOG FILE efdc.log
       ISPAR:   0 FOR EXECUTION OF CODE ON A SINGLE PROCESSOR MACHINE
              1 FOR PARALLEL EXECUTION, PARALLELIZING PRIMARILY OVER LAYERS
              2 FOR PARALLEL EXECUTION, PARALLELIZING PRIMARILY OVER
              NDM HORIZONTAL GRID SUBDOMAINS, SEE CARD CARD C9
       ISDIVEX: 1 FOR WRITING EXTERNAL MODE DIVERGENCE TO SCREEN
       ISNEGH:  1 FOR SEARCHING FOR NEGATIVE DEPTHS AND WRITING TO SCREEN
       ISMMC:   1 FOR WRITING MIN AND MAX VALUES OF SALT AND DYE
              CONCENTRATION TO SCREEN
       ISBAL:   1 FOR ACTIVATING MASS, MOMENTUM AND ENERGY BALANCES AND
              WRITING RESULTS TO FILE bal.out
       ISHP:    1 FOR CALLING HP 9000 S700 VERSIONS OF CERTAIN SUBROUTINES
       ISH0W:   1 TO SHOW PUV&S ON SCREEN, SEE INSTRUCTIONS FOR FILE show.inp
C
```

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C2 ISRESTI ISRESTO ISRESTR ISPAR ISLOG ISDIVEX ISNEGH ISMMC ISBAL ISHP ISHOW
      1   1   0   0   2   0   2   0 0 0 1

C3 EXTERNAL MODE SOLUTION OPTION PARAMETERS AND SWITCHES
C
     RP: OVER RELAXATION PARAMETER
     RSQM: TRAGET SQUARE RESIDUAL OF ITERATIVE SOLUTION SCHEME
     ITERM: MAXIMUN NUMBER OF ITERARTIONS
     IRVEC: 0 STANDARD RED-BLACK SOR SOLUTION
            1 MORE VECTORIZABLE RED-BLACK SOR (FOR RESEARCH PURPOSES)
            2 RED-BLACK ORDERED CONJUGATE GRADIENT SOLUTION
            3 REDUCED SYSTEM R-B CONJUGATE GRADIENT SOLUTION
            9 NON-DRYING CON GRADIENT SOLUTION WITH MAXIMUM DIAGNOSTICS
     RPADJ: RELAXATION PARAMETER FOR AUXILLARY POTENTIAL ADJUSTME
            OF THE MEAN MASS TRANSPORT ADVECTION FIELD
            (FOR RESEARCH PURPOSES)
     RSQMADJ: TRAGET SQUARED RESIDUAL ERROR FOR ADJUSTMENT
            (FOR RESEARCH PURPOSES)
     ITRMADJ: MAXIMUM ITERARTIONS FOR ADJUSTMENT(FOR RESEARCH PURPOSES)
     ITERHPM: MAXIMUM ITERATIONS FOR STRONGLY NONLINER DRYING AND WETTING
            SCHEME (ISDRY=3 OR OR 4) ITERHPM.LE.4
     IDRYCK: ITERATIONS PER DRYING CHECK (ISDRY.GE.1) 2.LE.IDRYCK.LE.20
     ISDSOLV: 1 TO WRITE DIAGNOSTICS FILES FOR EXTERNAL MODE SOLVER
       FILT: FILTER COEFFICIENT FOR 3 TIME LEVEL EXPLICIT (0.0625)
C   1.E-3   9
C3 RP RSQM   ITERM IRVEC RPADJ RSQMADJ ITRMADJ ITERHPM IDRYCK ISDSOLV FILT
     1.8 1.E-16 200 9   1.8 1.E-16 1000   0   20   0   0.0625

C4 LONGTERM MASS TRANSPORT INTEGRATION ONLY SWITCHES
C
     ISLTMT: 1 FOR LONG-TERM MASS TRANSPORT ONLY (FOR RESEARCH PURPOSES)
     ISSSMMT: 0 WRITES MEAN MASS TRANSPORT TO restran.out AFTER EACH
            AVERAGING PERIOD (FOR RESEARCH PURPOSES)
            1 WRITES MEAN MASS TRANSPORT TO restran.out AFTER LAST
            AVERAGING PERIOD (FOR RESEARCH PURPOSES)
     ISLTMTS: 0 ASSUMES LONG-TERM TRANSPORT SOLUTION IS TRANSIENT
            (FOR RESEARCH PURPOSES)
            1 ASSUMES LONG-TERM TRANSPORT SOLUTION IS ITERATED TOWARD
            STEADY STATE (FOR RESEARCH PURPOSES)
     ISIA: 1 FOR IMPLICIT LONG-TERM ADVECTION INTEGRATION FOR ZEBRA
            VERTICAL LINE R-B SOR (FOR RESEARCH PURPOSES)
     RPIA: RELAXATION PARAMETER FOR ZEBRA SOR(FOR RESEARCH PURPOSES)
     RSQMIA: TRAGET RESIDUAL ERROR FOR ZEBRA SOR (FOR RESEARCH PURPOSES)
     ITRMIA: MAXIMUM ITERATIONS FOR ZEBRA SOR (FOR RESEARCH PURPOSES)
     ISAVEC: 1 USE ALTIVEC ENABLED SUBROUTINES (MAC G4 ONLY)
C
C4 ISLTMT ISSSMMT ISLTMTS ISIA RPIA RSQMIA   ITRMIA
      0   1   0   0   1.8 1.E-10 100   0

C5   MOMENTUM ADVEC AND HORIZ DIFF SWITCHES AND MISC SWITCHES
C
     ISCDMA: 1 FOR CENTRAL DIFFERENCE MOMENTUM ADVECTION
            0 FOR UPWIND DIFFERENCE MOMENTUM ADVECTION
            2 FOR EXPERIMENTAL UPWIND DIFF MOM ADV (FOR RESEACH PURPOSES)
     ISHDMF: 1 TO ACTIVE HORIZONTAL MOMENTUM DIFFUSION
     ISDISP: 1 CALCULATE MEAN HORIZONTAL SHEAR DISPERSION TENSOR OVER LAST
            MEAN MASS TRANSPORT AVERAGING PERIOD
     ISWASP: 4 or 5 TO WRITE FILES FOR WASP4 or WASP5 MODEL LINKAGE
     ISDRY: GREATER THAN 0 TO ACTIVE WETTING & DRYING OF SHALLOW AREAS
            1 CONSTANT WETTING DEPTH SPECIFIED BY HWET ON CARD 11
            WITH NONLINEAR ITERATIONS SPECIFIED BY ITERHPM ON CARD C3
            2 VARIABLE WETTING DEPTH CALCULATED INTERNALLY IN CODE
            WITH NONLINEAR ITERATIONS SPECIFIED BY ITERHPM ON CARD C3
            11 SAME AS 1, WITHOUT NONLINEAR ITERATION
            12 SAME AS 2, WITHOUT NONLINEAR ITERATION
            3 DIFFUSION WAVE APPROX, CONSTANT WETTING DEPTH (NOT ACTIVE)

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                4 DIFFUSION WAVE APPROX, VARIABLE WETTING DEPTH (NOT ACTIVE)
      ISQQ:    1 TO USE STANDARD TURBULENT INTENSITY ADVECTION SCHEME
      ISRLID:  1 TO RUN IN RIGID LID MODE (NO FREE SURFACE)
      ISVEG:   1 TO IMPLEMENT VEGETATION RESISTANCE
               2 IMPLEMENT WITH DIAGNOSTICS TO FILE cbot.log
      ISVEGL:  1 TO INCLUDE LAMINAR FLOW OPTION IN VEGETATION RESISTANCE
      ISITB:   1 FOR IMPLICIT BOTTOM & VEGETATION RESISTANCE IN EXTERNAL MODE
               FOR SINGLE LAYER APPLICATIONS (KC=1) ONLY
      ISEVER:  1 TO DEFAULT TO EVERGLADES HYDRO SOLUTION OPTIONS
     IINTPG:   0 ORIGINAL INTERNAL PRESSURE GRADIENT FORMULATION
               1 JOCABIAN FORMULATION
               2 FINITE VOLUME FORMULATION
C                11
C5 ISCDMA ISHDMF ISDISP ISWASP ISDRY ISQQ ISRLID ISVEG ISVEGL ISITB ISEVER iintpg
    0    0    0    0   99   1   0    0    0    1   0    0
--------------------------------------------------------------------------------
C6   DISSOLVED AND SUSPENDED CONSTITUENT TRANSPORT SWITCHES
C6   TURB INT=0,SAL=1,TEM=2,DYE=3,SFL=4,TOX=5,SED=6,SND=7,CWQ=8
C
     ISTRAN: 1 OR GREATER TO ACTIVATE TRANSPORT
     ISTOPT:   NONZERO FOR TRANSPORT OPTIONS, SEE USERS MANUAL
     ISCDCA: 0 FOR STANDARD DONOR CELL UPWIND DIFFERENCE ADVECTION
             1 FOR CENTRAL DIFFERENCE ADVECTION FOR THREE TIME LEVEL STEPS
             2 FOR EXPERIMENTAL UPWIND DIFFERENCE ADVECTION (FOR RESEARCH)
     ISADAC: 1 TO ACTIVATE ANTI-NUMERICAL DIFFUSION CORRECTION TO
             STANDARD DONOR CELL SCHEME
     ISFCT:  1 TO ADD FLUX LIMITING TO ANTI-NUMERICAL DIFFUSION CORRECTION
     ISPLIT: 1 TO OPERATOR SPLIT HORIZONTAL AND VERTICAL ADVECTION
             (FOR RESEARCH PURPOSES)
     ISADAH: 1 TO ACTIVATE ANTI-NUM DIFFUSION CORRECTION TO HORIZONTAL
             SPLIT ADVECTION STANDARD DONOR CELL SCHEME (FOR RESEARCH)
     ISADAV: 1 TO ACTIVATE ANTI-NUM DIFFUSION CORRECTION TO VERTICAL
             SPLIT ADVECTION STANDARD DONOR CELL SCHEME (FOR RESEARCH)
     ISCI:   1 TO READ CONCENTRATION FROM FILE restart.inp
     ISCO:   1 TO WRITE CONCENTRATION TO FILE restart.out
C
C6   ISTRAN ISTOPT ISCDCA ISADAC ISFCT ISPLIT ISADAH ISADAV ISCI ISCO
     1    1    0    0    0    0    0    0    0   0   !turb 0
     0    0    0    1    1    0    0    0    0   0   !sal  1
     1    1    0    1    1    0    0    0    0   0   !tem  2
     0    0    0    1    1    0    0    0    0   0   !dye  3
     0    0    0    1    1    0    0    0    0   0   !sfl  4
     0    0    0    1    1    0    0    0    0   0   !tox  5
     0    0    0    1    1    0    0    0    0   0   !sed  6
     0    0    0    1    1    0    0    0    0   0   !snd  7
     1    0    0    1    1    0    0    0    0   0   !cwq  8
--------------------------------------------------------------------------------
C7 TIME-RELATED INTEGER PARAMETERS
C
     NTC:    NUMBER OF REFERENCE TIME PERIODS IN RUN
     NTSPTC: NUMBER OF TIME STEPS PER REFERENCE TIME PERIOD
     NLTC:   NUMBER OF LINEARIZED REFERENCE TIME PERIODS
     NLTC:   NUMBER OF TRANSITION REF TIME PERIODS TO FULLY NONLINEAR
     NTCPP:  NUMBER OF REFERENCE TIME PERIODS BETWEEN FULL PRINTED OUTPUT
             TO FILE efdc.out
     NTSTBC: NUMBER OF REFERENCE TIME PERIODS BETWEEN TWO TIME LEVEL
             TRAPEZOIDAL CORRECTION TIME STEP
     NTCNB:  NUMBER OF REFERENCE TIME PERIODS WITH N0 BUOYANCY FORCING
     NTCVB:  NUMBER OF REF TIME PERIODS WITH VARIABLE BUOYANCY FORCING
     NTCMMT: NUMBER OF NUMBER OF REF TIME TO AVERAGE OVER TO OBTAIN
             RESIDUAL OR MEAN MASS TRANSPORT VARIABLES
     NFLTMT: USE 1 (FOR RESEARCH PURPOSES)
     NDRYSTP: MIN NO. OF TIME STEPS A CELL REMAINS DRY AFTER INTIAL DYRING
C  2678  21600
C7 NTC  NTSPTC NLTC NTTC NTCPP NTSTBC NTCNB NTCVB NTSMMT NFLTMT NDRYSTP
   2678 14400  0   0  800    8   0    0   720    1    16
```

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--------------------------------------------------------------------------
C8  TIME-RELATED REAL PARAMETERS
C

    TCON:    CONVERSION MULTIPLIER TO CHANGE TBEGIN TO SECONDS
    TBEGIN:  TIME ORIGIN OF RUN
    TREF:    REFERENCE TIME PERIOD IN SEC (ie 44714.16s or 86400s)
    CORIOLIS: CONSTANT CORIOLIS PARAMETER IN 1/SEC
    ISCORV:  1 TO READ VARIABLE CORIOLIS COEFFICIENT FROM lxly.inp FILE
    ISCCA:   WRITE DIAGNOSTICS FOR MAX CORIOLIS-CURV ACCEL TO FILEefdc.log
    ISCFL:   1 WRITE DIAGNOSTICS OF MAX THEORETICAL TIME STEP TO cfl.out
             GT 1 TIME STEP ONLY AT INTERVAL ISCFL FOR ENTIRE RUN
    ISCFLM:  1 TO MAP LOCATIONS OF MAX TIME STEPS OVER ENTIRE RUN
    DTSSFAC: DYNAMIC TIME STEPPING IF 0.0.LT.DTSSFAC.LT.1.0
    DTSSDHDT: DYNAMIC TIME STEPPING RATE OF DEPTH CHANGE FACTOR
      7306=1jan2000  7579=1oct2000  8280=1sept2002  7550=1sept2000                 MaxCour
C8  TCON TBEGIN  TREF  CORIOLIS  ISCORV  ISCCA ISCFL ISCFLM DTSSFAC DTSSDHDT
   86400. 7550.0 86400. 0.00000   0     0     0    0    0.0    1.0
--------------------------------------------------------------------------
C9  SPACE-RELATED AND SMOOTHING  PARAMETERS
C

    IC:     NUMBER OF CELLS IN I DIRECTION
    JC:     NUMBER OF CELLS IN J DIRECTION
    LC:     NUMBER OF ACTIVE CELLS IN HORIZONTAL + 2
    LVC:    NUMBER OF VARIABLE SIZE HORIZONTAL CELLS
    ISCO:   1 FOR CURVILINEAR-ORTHOGONAL GRID (LVC=LC-2)
    NDM:    NUMBER OF DOMAINS FOR HORIZONTAL DOMAIN DECOMPOSITION
           ( NDM=1, FOR MODEL EXECUTION ON A SINGLE PROCESSOR SYSTEM OR
             NDM=MM*NCPUS, WHERE MM IS AN INTEGER AND NCPUS IS THE NUMBER
             OF AVAILABLE CPU's FOR MODEL EXECUTION ON A PARALLEL
             MULTIPLE PROCESSOR SYSTEM )
    LDW:    NUMBER OF WATER CELLS PER DOMAIN
           ( LDW=(LC-2)/NDM, FOR MULTIPE VECTOR PROCESSORS, LWD MUST BE
             AN INTEGER MULTIPLE OF THE VECTOR LENGTH OR STRIDE NVEC
             THUS CONSTRAINING LC-2 TO BE AN INTEGER MULTIPLE OF NVEC )
    ISMASK: 1 FOR MASKING WATER CELL TO LAND OR ADDING THIN BARRIERS
            USING INFORMATION IN FILE mask.inp
    ISPGNS: 1 FOR IMPLEMENTING A PERIODIC GRID IN COMP N-S DIRECTION OR
            CONNECTING ARBITRATY CELLS USING INFO IN FILE mappgns.inp
    NSHMAX: NUMBER OF DEPTH SMOOTHING PASSES
    NSBMAX: NUMBER OF INITIAL SALINITY FIELD SMOOTHING PASSES
    WSMH:   DEPTH SMOOTHING WEIGHT
    WSMB:   SALINITY SMOOTHING WEIGHT
C
C9  IC  JC  LC  LVC ISCO NDM LDW ISMASK ISPGNS NSHMX NSBMX  WSMH   WSMB
   10 570 1778  1776  1   1 1776 0     0     0     0    0.0625 0.0625
--------------------------------------------------------------------------
C9A  VERTICAL SPACE-RELATED PARAMETERS
C
   KC:     NUMBER OF VERTICAL LAYER
   KSIG:    NUMBER OF VERTICAL LAYERS IN SIGMA REGION FOR IGRIDV = 1
  ISETGVC;   0 READ BOTTOM LAYER ID FROM GVCLAYER.INP
            1 AUTOMATICALLY SET BOTTOM LAYER ID USING SELVREF, SELVREF
                    AND BELV (IN DXDY.INP) AND WRITE RESULTS TO GVCLAYER.OUT
  SELVREF:    REFERENCE SURFACE ELEVATION IN RESCALED HEIGHT REGION (METERS)
  BELVREF:    REFERENCE (MINIMUM) BOTTOM ELEVATION IN RESCALED HEIGHT REGION
  ISGVCCK:    0 NORMAL SETTING (OPTION 1 USED FOR DEBUGGING SIGMA/GVC COMPARE)
            1 USE MULTI-LAYER BOTTOM FRICTION FOR SINGLE LAYER SIGMA
C
C9A KC KSIG ISETGVC  SELVREF  BELVREF  ISGVCCK
    1  0    0     0      0      0
--------------------------------------------------------------------------
C10 LAYER THICKNESS IN VERTICAL
C
     K: LAYER NUMBER, K=1,KC
     DZC: DIMENSIONLESS LAYER THICKNESS (THICKNESSES MUST SUM TO 1.0)
           FOR IGRIDV=1, THE TOP KSIG LAYERS ARE PRESENT IN BOTH THE
```

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SIGMA AND RESCALED HEIGHT REGIONS
```
C
C10   K      DZC
      1     1.0
```

```
C11 GRID, ROUGHNESS AND DEPTH PARAMETERS
C
    DX:     CARTESIAN CELL LENGTH IN X OR I DIRECTION
    DY:     CARTESION CELL LENGHT IN Y OR J DIRECTION
    DXYCVT: MULTIPLY DX AND DY BY TO OBTAIN METERS
    IMD:    GREATER THAN 0 TO READ MODDXDY.INP FILE
    ZBRADJ: LOG BDRY LAYER CONST OR VARIABLE ROUGH HEIGHT ADJ IN METERS
    ZBRCVRT: LOG BDRY LAYER VARIABLE ROUGHNESS HEIGHT CONVERT TO METERS
    HMIN:   MINIMUM DEPTH OF INPUTS DEPTHS IN METERS
    HADJ:   ADJUCTMENT TO DEPTH FIELD IN METERS
    HCVRT:  CONVERTS INPUT DEPTH FIELD TO METERS
    HDRY:   DEPTH AT WHICH CELL OR FLOW FACE BECOMES DRY
    HWET:   DEPTH AT WHICH CELL OR FLOW FACE BECOMES WET
    BELADJ: ADJUCTMENT TO BOTTOM BED ELEVATION FIELD IN METERS
    BELCVRT: CONVERTS INPUT BOTTOM BED ELEVATION FIELD TO METERS
C                            0.11  0.16
C11 DX  DY DXYCVT IMD  ZBRADJ ZBRCVT HMIN HADJ HCVT HDRY  HWET  BELADJ BELCVT
    1. 1. 1.   0    0.04  0.0   0.1 0.0 1.0 0.05 0.06 -0.0  1.00
```

```
C11A TWO-LAYER MOMENTUM FLUX AND CURVATURE ACCELERATION CORRECTION FACTORS
C
    ICK2COR: 0 NO CORRECTION
    ICK2COR: 1 CORRECTION USING CK2UUC,CK2VVC,CK2UVC FOR CURVATURE
    ICK2COR: 2 CORRECTION USING CK2FCX,CK2FCY FOR CURVATURE
    CK2UUM: CORRECTION FOR UU MOMENTUM FLUX
    CK2VVM: CORRECTION FOR UU MOMENTUM FLUX
    CK2UVM: CORRECTION FOR UU MOMENTUM FLUX
    CK2UUC: CORRECTION FOR UU CURVATURE ACCELERATION
    CK2VVC: CORRECTION FOR VV CURVATURE ACCELERATION
    CK2UVC: CORRECTION FOR UV CURVATURE ACCELERATION
    CK2FCX: CORRECTION FOR X EQUATION CURVATURE ACCELERATION
    CK2FCY: CORRECTION FOR Y EQUATION CURVATURE ACCELERATION
C
C11A ICK2COR  CK2UUM  CK2VVM  CK2UVM  CK2UUC  CK2VVC  CK2UVC  CK2FCX  CK2FCY
     0    0.0825 0.0825 0.0825 0.0825 0.0825 0.0825 0.0825 0.0825
```

```
C11B CORNER CELL BED STRESS CORRECTION

   ISCORTBC: 1 TO CORRECT BED STRESS AVERAGEING TO CELL CENTERS IN CORNERS
            2 TO USE SPATIALLY VARYING CORRECTION FOR CELLS IN CORNERC.INP
   ISCORTBCD: 1 WRITE DIAGNOSTICS EVERY NSPTC TIME STEPS
   FSCORTBC: CORRECTION FACTOR, 0.0 LE FSCORTBC LE 1.0
        1.0 = NO CORRECTION, 0.0 = MAXIMUM CORRECTION, 0.5 SUGGESTED
C
C11B ISCORTBC ISCORTBCD FSCORTBC
     0     1      0.414
```

```
C12 TURBULENT DIFFUSION PARAMETERS
C
    AHO:    CONSTANT HORIZONTAL MOMENTUM AND MASS DIFFUSIVITY M*M/S
    AHD:    DIMESIONLESS HORIZONTAL MOMENTUM DIFFUSIVITY
    AVO:    BACKGROUND, CONSTANT OR MOLECULAR KINEMATIC VISCOSITY M*M/S
    ABO:    BACKGROUND, CONSTANT OR MOLECULAR DIFFUSIVITY M*M/S
    AVMN:   MINIMUM KINEMATIC EDDY VISCOSITY M*M/S
    ABMN:   MINIMUM EDDY DIFFUSIVITY M*M/S
    VISMUD: CONSTANT FLUID MUD VISCOSITY M*M/S
    AVBCON: EQUALS ZERO FOR CONSTANT VERTICAL VISCOSITY AND DIFFUSIVITY
         WHICH ARE SET EQUAL TO AVO AND ABO OTHERWISE SET TO 1.0
    ZBRWALL: SIDE WALL LOG LAW ROUGHNESS HEIGHT. USED WHEN HORIZONTAL
         MOMENTUM DIFFUSION IS ACTIVE AND AHO OR AHD ARE NONZERO
C       1.E-6  1.E-9  1.E-6  1.E-9
```

C12 AHO AHD AVO   ABO   AVMN ABMN VISMUD AVBCON ZBRWALL
   0.0 0.0 1.E-6 1.4E-7 1E-6 1.4E-7 1.e-6 1.0   0.0

C12A TURBULENCE CLOSURE OPTIONS
C
     ISSTAB: 0 FOR GALPERIN ET AL STABILTIY FUNCTIONS IN CALAVBOLD
              1 FOR GALPERIN ET AL STABILTIY FUNCTIONS
              2 FOR KANTHA AND CLAYSON (1994) STABILTIY FUNCTIONS
              3 FOR KANTAH (2003) STABILITY FUNCTIONS
               NOTE OPTIONS SELECTED HERE OVER RIDE ISTOPT(0) ON C6
     ISSQL: 0 SETS QQ AND QQL STABILITY FUNCTIONS PROPORTIONAL TO
                 MOMENTUM STABILITY FUNCTIONS (EXCEPT FOR ISSTAB=3)
                        1 SETS QQ AND QQL STABILITY FUNCTIONS TO CONSTANTS
                            (FOR ISSTAB = 0,1,2) THIS OPTION NOT ACTIVE
     ISAVBMN: SET TO 1 TO ACTIVATE MIN VIS AND DIFF OF AVMN AND ABMN
     ISFAVB: SET TO 1 OR 2 TO AVG OR SQRT FILTER AVV AND AVB
     ISINWV: SET TO 1 TO ACTIVATE INTERNAL WAVE PARAMETERIZATION
     ISLLIM: 0 FOR NO LENGHT SCALE AND RIQMAX LIMITATIONS
              1 LIMIT RIQMAX IN STABILITY FUNCTION ONLY
              2 DIRECTLY LIMIT LENGTH SCALE AND LIMIT RIQMAX IN STAB FUNC
     IFPROX: 0 FOR NO WALL PROXIMITY FUNCTION
              1 FOR PARABOLIC OVER DEPTH WALL PROXIMITY FUNCITON
              2 FOR OPEN CHANNEL WALL PROXIMITY FUNCITON
     ISVTURB: SET TO 1 TO INCLUDE VEGETATION GENERATED TURBULENCE PRODUCTION
              VTURBEFF: EFFICIENCY FACTOR FOR VEGETATION TURBULENCE PRODUCTION (0,1)
C
C12A ISSTAB ISSQL ISAVBMN ISFAVB ISINWV ISLLIM IFPROX ISVTURB VTURBEFF
     1   0   0   2   0   1   2   0   0.0

C13 TURBULENCE CLOSURE PARAMETERS
C
     VKC: VON KARMAN CONSTANT
     CTURB1: TURB CONSTANT, B1 USE 16.6 FOR ALL CLOSURES
     CTURB2: TURB CONSTANT, B2 USE 10.1 FOR ALL CLOSURES
     CTE1:   TURB CONSTANT E1 FOR SHEAR PRODUCTION IN Q*Q*L EQ.
     CTE2:   TURB CONSTANT E2 DISSIPATION IN Q*Q*L EQ. USE 1.0
     CTE3:   TURB CONSTANT E3 (SOMETIMES CALL E2)BOUYANCY TERM IN Q*Q*L EQ.
     CTE4:   TURB CONSTANT E4 (SOMETIMES CALL E3)WALL FUNCTION IN Q*Q*L EQ.
     CTE5:   TURB CONSTANT E5 2ND OPEN CHANNEL WALL FUNCTION IN Q*Q*L EQ.
     RIQMAX: MAXIMUM TURB INTENSITY RICHARDSON NUMBER FOR STABLE CONDITIONS
     QQMIN: MINIMUM TURBULENT INTENSITY SQUARED
     QQLMIN: MINIMUM TURBULENT INTENSITY SQUARED TIMES MACRO-SCALE
     DMLMIN: MINIMUM DIMENSIONLESS MACRO-SCALE
C   1.8 1.0 1.8/5. 1.33 0.25   1.E-8 1.E-12 1.E-4
C13 VKC CTURB1 CTURB2 CTE1 CTE2 CTE3 CTE4 CTE5 RIQMAX QQMIN QQLMIN DMLMIN
   0.4 16.6 10.1 1.8 1.0 1.8 1.33 0.25 0.28 1.E-8 1.E-12 1.E-4

C14 TIDAL & ATMOSPHERIC FORCING, GROUND WATER AND SUBGRID CHANNEL PARAMETERS
C
     MTIDE: NUMBER OF PERIOD (TIDAL) FORCING CONSTITUENTS
     NWSER: NUMBER OF WIND TIME SERIES (0 SETS WIND TO ZERO)
     NASER : NUMBER OF ATMOSPHERIC CONDITION TIME SERIES (0 SETS ALL ZERO)
     ISGWI: 1 TO ACTIVATE SOIL MOISTURE BALANCE WITH DRYING AND WETTING
              2 TO ACTIVATE GROUNDWATER INTERACTION WITH BED AND WATER COL
     ISCHAN: 1 ACTIVATE SUBGRID CHANNEL MODEL AND READ MODCHAN.INP
     ISWAVE: 1 FOR WAVE CURRENT BOUNDARY LAYER REQUIRES FILE wave.inp
              2 FOR WCBL AND WAVE INDUCED CURRENTS REQUIRES FILE wave.inp
     ITIDASM: 1 FOR TIDAL ELEVATION ASSIMILATION (NOT ACTIVE)
     ISPERC: 1 TO PERCOLATE OR ELIMINATE EXCESS WATER IN DRY CELLS
     ISBODYF: TO INCLUDE EXTERNAL MODE BODY FORCES FROM FBODY.INP
              1 FOR UNIFORM OVER DEPTH, 2 FOR SURFACE LAYER ONLY
     ISPNHYDS: 1 FOR QUASI-NONHYDROSTATIC OPTION
C
C14 MTIDE NWSER NASER ISGWI ISCHAN ISWAVE ITIDASM ISPERC ISBODYF ISPNHYDS
   0   7   7   0   0   0   0   0   0   0   0

C15 PERIODIC FORCING (TIDAL) CONSTITUENT SYMBOLS AND PERIODS
C
    SYMBOL: FORCING SYMBOL (CHARACTER VARIABLE) FOR TIDES, THE NOS SYMBOL
    PERIOD: FORCING PERIOD IN SECONDS
C
C15 SYMBOL   PERIOD

C16 SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITION PARAMETERS
C
    NPBS: NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
        CELLS ON SOUTH OPEN BOUNDARIES
    NPBW: NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
        CELLS ON WEST OPEN BOUNDARIES
    NPBE: NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
        CELLS ON EAST OPEN BOUNDARIES
    NPBN: NUMBER OF SURFACE ELEVATION OR PRESSURE BOUNDARY CONDITIONS
        CELLS ON NORTH OPEN BOUNDARIES
    NPFOR: NUMBER OF HARMONIC FORCINGS
    NPFORT: FORCING TYPE, 0=CONSTANT, 1=LINEAR, 2= QUADRATIC VARIATION
    NPSER: NUMBER OF TIME SERIES FORCINGS
    PDGINIT: ADD THIS CONSTANT ADJUSTMENT GLOBALLY TO THE SURFACE ELEVATION
C
C16 NPBS NPBW NPBE NPBN NPFOR NPFORT NPSER PDGINIT ggg
    0 0 0 0 0   0 0   0.0   0

C17 PERIODIC FORCING (TIDAL) SURF ELEV OR PRESSURE BOUNDARY COND. FORCINGS
C
    NPFOR: FORCING NUMBER
    SYMBOL: FORCING SYMBOL (FOR REFERENCE HERE ONLY)
    AMPLITUDE: AMPLITUDE IN M (PRESSURE DIVIDED BY RHO*G), NPFORT=0
        COSINE AMPLITUDE IN M, NPFORT.GE.1
    PHASE: FORCING PHASE RELATIVE TO TBEGIN IN SECONDS, NPFORT=0
        SINE AMPLITUDE IN M, NPFORT.GE.1
    NOTE: FOR NPFORT=0 SINGLE AMPLITUDE AND PHASE ARE READ, FOR NPFORT=1
      CONST AND LINEAR COS AND SIN AMPS ARE READ FOR EACH FORCING, FOR
      NPFORT=2, CONST, LINEAR, QUAD COS AND SIN AMPS ARE READ FOR EACH
      FOR EACH FORCING
C   0.30
C17 NPFOR   SYMBOL   AMPLITUDE   PHASE

C18 PERIODIC FORCING (TIDAL) SURF ELEV OR PRESSURE ON SOUTH OPEN BOUNDARIES
C
    IPBS: I CELL INDEX OF BOUNDARY CELL
    JPBS: J CELL INDEX OF BOUNDARY CELL
    ISPBS: 0 FOR ELEVATION SPECIFIED
        1 FOR RADIATION-SEPARATION CONDITION, ZERO TANGENTIAL VELOCITY
        2 FOR RADIATION-SEPARATION CONDITION, FREE TANGENTIAL VELOCITY
    NPFORS: APPLY HARMONIC FORCING NUMBER NPFORS
    NPSERS: APPLY TIME SERIES FORCING NUMBER NPSERS
    TPCOORDS: TANGENTIAL COORIDATE ALONG BOUNDARY (NPFORT.GE.1)
C
C18 IPBS   JPBS   ISPBS   NPFORS   NPSERS TPCOORDS

C19 PERIODIC FORCING (TIDAL) SURF ELEV OR PRESSURE ON WEST OPEN BOUNDARIES
C
    IPBW: SEE CARD 19
    JPBW:
    ISPBW:
    NPFORW:
    NPSERW:
    TPCOORDW:
C
C19 IPBW   JPBW ISPBW NPFORW   NPSERW TPCOORDW

C20 PERIODIC FORCING (TIDAL) SURF ELEV OR PRESSURE ON EAST OPEN BOUNDARIES
C

```
    IPBE:  SEE CARD 19
    JPBE:
    ISPBE:
    NPFORE:
    NPSERE:
    TPCOORDE:
C
C20 IPBE JPBE ISPBE NPFORE   NPSERE  TPCOORDE
---------------------------------------------------------------------------
C21 PERIODIC FORCING (TIDAL) SURF ELEV OR PRESSURE ON NORTH OPEN BOUNDARIES
C
    IPBN:  SEE CARD 19
    JPBN:
    ISPBN:
    NPFORN:
    NPSERN:
    TPCOORDN:
C
C21 IPBN    JPBN  ISPBN  NPFORN  NPSERN
---------------------------------------------------------------------------
C21A WATER SURFACE ELEVATION AND VELOCITY DATA ASSIMILATION
C
    ISWSEDA: 1 FOR WATER SURFACE ELEVATION DATA ASSIMILATION
    NLWSEDA :  NUMBER OF LOCATIONS FOR WATER SURFACE ELEVATION ASSIMILAITON
    ISUVDA:  1 FOR BAROTROPIC VELOCITY DATA ASSIMILAITON
            2 FOR LAYERED VELOCITY DATA ASSIMILAITON
    NLUVDA :  NUMBER OF LOCATIONS FOR VELOCITY DATA ASSIMILAITON
        NUVSER:   NUMBER OF HORIZONTAL VELOCITY VECTOR TIME SERIES
C
C21A  ISWSEDA NLWSEDA ISUVDA NLUVDA NUVSER
       0     0     0     0    0
---------------------------------------------------------------------------
C21B WATER SURFACE ELEVATION DATA ASSIMILATION  (NO DATA IS ISWESDA=0)
C
    IWSEDA:    I CELL INDEX FOR WATER SURFACE ELEV DATA ASSIMILAITON
    JWSEDA:    J CELL INDEX FOR WATER SURFACE ELEV DATA ASSIMILAITON
    NWSESERA:   TIME SERIES ID FOR WATER SURFACE ELEVATION ASSIMILATION
    TSWSEA:    WEIGHTING FACTOR, 0.- 1., 1. = FULL ASSIMILATION
C
C21B ICWSEDA   JCWSEDA  NWSESERA  TSWSEDA
---------------------------------------------------------------------------
C21C VELOCITY DATA ASSIMILATION  (NO DATA IF ISUVDA=0)
C
    IUVDA:   I CELL INDEX FOR VELOCITY DATA ASSIMILAITON
    JUVDA:   J CELL INDEX FOR VELOCITY DATA ASSIMILAITON
    NUVSERA:   TIME SERIES ID FOR VELOCITY DATA ASSIMILATION
    TSUVDA:    WEIGHTING FACTOR, 0.- 1., 1. = FULL ASSIMILATION
    FSUVDA:    IMPLICITNESS FACTOR, 0 EXPLICIT, 1 IMPLICIT
    IWUVDA:    0 NO ZONAL, 1 INVERSE ZONE, 2 INVERSE SQUARE ZONE
    IRUVDA:    I,J ZONE RADIUS OF INFLUENCE
    RRUVDA:    DX,DY ZONE RADIUS OF INFLUECE (NONE ZERO TO USE)
C
C21C ICUVDA  JCUVDA  NUVSERA  TSUVDA  FSUVDA  IWUVDA  IRUVDA  RRUVDA
---------------------------------------------------------------------------
C22 SPECIFY NUM OF SEDIMENT AMD TOXICS AND NUM OF CONCENTRATION TIME SERIES
C
    NTOX:  NUMBER OF TOXIC CONTAMINANTS (DEFAULT = 1)
    NSED:  NUMBER OF COHESIVE SEDIMENT SIZE CLASSES (DEFAULT = 1)
    NSND:  NUMBER OF NON-COHESIVE SEDIMENT SIZE CLASSES (DEFAULT = 1)
    NSSER: NUMBER OF SALINITY TIME SERIES
    NTSER: NUMBER OF TEMPERATURE TIME SERIES
    NDSER: NUMBER OF DYE CONCENTRATION TIME SERIES
    NSFSER: NUMBER OF SHELLFISH LARVAE CONCENTRATION TIME SERIES
    NTXSER: NUMBER OF TOXIC CONTAMINANT CONCENTRATION TIME SERIES
        EACH TIME SERIES MUST HAVE DATA FOR NTOX TOXICICANTS
    NSDSER: NUMBER OF COHESIVE SEDIMENT CONCENTRATION TIME SERIES
```

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            EACH TIME SERIES MUST HAVE DATA FOR NSED COHESIVE SEDIMENTS
        NSNSER: NUMBER OF NONCOHESIVE SEDIMENT CONCENTRATION TIME SERIES
            EACH TIME SERIES MUST HAVE DATA FOR NSND NON-COHESIVE SEDIMENTS
        ISDBAL: SET TO 1 FOR SEDIENT MASS BALANCE
C
C22  NTOX NSED  NSND  NSSER NTSER NDSER NSFSER NTXSER NSDSER NSNSER ISSBAL
      0   0   0   0   1   0   0   0   0   0   0
--------------------------------------------------------------------------------
C23 VELOCITY, VOLUMN SOURCE/SINK, FLOW CONTROL, AND WITHDRAWAL/RETURN DATA
C
     NQSIJ:  NUMBER OF CONSTANT AND/OR TIME SERIES SPECIFIED SOURCE/SINK
        LOCATIONS (RIVER INFLOWS,ETC)           .
     NQJPIJ: NUMBER OF CONSTANT AND/OR TIME SERIES SPECIFIED SOURCE
        LOCATIONS TREATED AS JETS/PLUMES         .
     NQSER:  NUMBER OF VOLUMN SOURCE/SINK TIME SERIES
     NQCTL:  NUMBER OF PRESSURE CONTROLED WITHDRAWAL/RETURN PAIRS
     NQCTLT: NUMBER OF PRESSURE CONTROLED WITHDRAWAL/RETURN TABLES
     NQWR:   NUMBER OF CONSTANT OR TIME SERIES SPECIFIED WITHDRAWL/RETURN
        PAIRS             .
     NQWRSR: NUMBER OF TIME SERIES SPECIFYING WITHDRAWL,RETURN AND
        CONCENTRATION RISE SERIES
     ISDIQ:  SET TO 1 TO WRITE DIAGNOSTIC FILE, diaq.out
C
C23  NQSIJ NQJPIJ NQSER NQCTL NQCTLT NQWR NQWRSR  ISDIQ
      16   0   27   1   1   0   0   0
--------------------------------------------------------------------------------
C24 VOLUMETRIC SOURCE/SINK LOCATIONS, MAGNITUDES, AND CONCENTRATION SERIES
C
     IQS:     I CELL INDEX OF VOLUME SOURCE/SINK
     JQS:     J CELL INDEX OF VOLUME SOURCE/SINK
     QSSE:    CONSTANT INFLOW/OUTFLOW RATE IN M*M*M/S
     NQSMUL:  MULTIPLIER SWITCH FOR CONSTANT AND TIME SERIES VOL S/S
        = 0  MULT BY 1. FOR NORMAL IN/OUTFLOW (L*L*L/T)
        = 1  MULT BY DY FOR LATERAL IN/OUTFLOW (L*L/T) ON U FACE
        = 2  MULT BY DX FOR LATERAL IN/OUTFLOW (L*L/T) ON V FACE
        = 3  MULT BY DX+DY FOR LATERAL IN/OUTFLOW (L*L/T) ON U&V FACES
     NQSMFF:  IF NON ZERO ACCOUNT FOR VOL S/S MOMENTUM FLUX
        = 1  MOMENTUM FLUX ON NEG U FACE
        = 2  MOMENTUM FLUX ON NEG V FACE
        = 3  MOMENTUM FLUX ON POS U FACE
        = 4  MOMENTUM FLUX ON POS V FACE
     NQSERQ:  ID NUMBER OF ASSOCIATED VOLUMN FLOW TIME SERIES
     NSSERQ:  ID NUMBER OF ASSOCIATED SALINITY TIME SERIES
     NTSERQ:  ID NUMBER OF ASSOCIATED TEMPERATURE TIME SERIES
     NDSERQ:  ID NUMBER OF ASSOCIATED DYE CONC TIME SERIES
     NSFSERQ: ID NUMBER OF ASSOCIATED SHELL FISH LARVAE RELEASE TIME SERIES
     NTXSERQ: ID NUMBER OF ASSOCIATED TOXIC CONTAMINANT CONC TIME SERIES
     NSDSERQ: ID NUMBER OF ASSOCIATED COHEASIVE SEDIMENT CONC TIME SERIES
     NSNSERQ: ID NUMBER OF ASSOCIATED NONCOHEASIVE SED CONC TIME SERIES
     QSFACTOR: FRACTION OF TIME SERIES FLOW NQSERQ ASSIGNED TO THIS CELL
C
C24 IQS  JQS  QSSE  NQSMUL NQSMFF NQSERQ NS- NT- ND- NSF- NTX- NSD- NSN- qsfactor
    6  446  0.0   0   0   1   0  1  0  0   0   0   0   5.17   !ns=1  Atimsowe_05ed002
    8   79  0.0   0   0   3   0  1  0  0   0   0   0   1.0    !ns=3  Blackmud_05DF003
    6  468  0.0   0   0   7   0  1  0  0   0   0   0   5.17   !ns=7  Moosehill_05ed003
    6  565  0.0   0   0  10   0  1  0  0   0   0   0   0.0    !ns=10 NSRdeercrk_05EF001
    4  220  0.0   0   0  17   0  1  0  0   0   0   0   5.17   !ns=17 Redwater_05EC005
    4  190  0.0   0   0  20   0  1  0  0   0   0   0   5.17   !ns=20 Sturgeon_05EA002
    6  500  0.0   0   0  22   0  1  0  0   0   0   0   5.17   !ns=22 Vermilion_05EE007
    4  267  0.0   0   0  23   0  1  0  0   0   0   0   5.17   !ns=23 Waskatenau_05EC002
    8   79  0.0   0   0  24   0  1  0  0   0   0   0   1.0    !ns=24 Whitemud_05DF006
    5    2  0.0   0   0  25   0  1  0  0   0   0   0   0.33   !ns=25 Upstream Inflow
    6    2  0.0   0   0  25   0  1  0  0   0   0   0   0.34   !ns=25 Upstream Inflow
    7    2  0.0   0   0  25   0  1  0  0   0   0   0   0.33   !ns=25 Upstream Inflow
    6    5  0.0   0   0  26   0  1  0  0   0   0   0  -1.0    !ns=26 Take out Devon
    6  146  0.0   0   0  27   0  1  0  0   0   0   0  -1.0    !ns=27 Take out Capital
```

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```
  6   15   0.0    0    0   26   0  1  0  0   0   0   0   1.0    !ns=26 Devon WWTP
  6  156   0.0    0    0   27   0  1  0  0   0   0   0   1.0    !ns=27 Capital Region WWTP
--------------------------------------------------------------------------------
C25 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT VOLUMETRIC SOURCES
C
      SAL: SALT CONCENTRATION CORRESPONDING TO INFLOW ABOVE
      TEM: TEMPERATURE CORRESPONDING TO INFLOW ABOVE
      DYE: DYE CONCENTRATION CORRESPONDING TO INFLOW ABOVE
      SFL: SHELL FISH LARVAE CONCENTRATION CORRESPONDING TO INFLOW ABOVE
      TOX: NTOX TOXIC CONTAMINANT CONCENTRATIONS CORRESPONDING TO
          INFLOW ABOVE  WRITTEN AS TOXC(N), N=1,NTOX A SINGLE DEFAULT
          VALUE IS REQUIRED EVEN IF TOXIC TRANSPORT IS NOT ACTIVE
C
C25 SAL TEM DYE SFL TOX1-20
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
      0. 20.   1.  0.  0.
--------------------------------------------------------------------------------
C26 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT VOLUMETRIC SOURCES
C
      SED: NSED COHESIVE SEDIMENT CONCENTRATIONS CORRESPONDING TO
          INFLOW ABOVE  WRITTEN AS SEDC(N), N=1,NSED. I.E., THE FIRST
          NSED VALUES ARE COHESIVE A SINGLE DEFAULT VALUE IS REQUIRED
          EVEN IF COHESIVE SEDIMENT TRANSPORT IS INACTIVE
      SND: NSND NON-COHESIVE SEDIMENT CONCENTRATIONS CORRESPONDING TO
          INFLOW ABOVE  WRITTEN AS SND(N), N=1,NSND. I.E., THE LAST
          NSND VALUES ARE NON-COHESIVE. A SINGLE DEFAULT VALUE IS
          REQUIRED EVEN IF NON-COHESIVE SEDIMENT TRANSPORT IS INACTIVE
C
C26 SED1  SND1
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
      0.   0.   0.   0.   0.
--------------------------------------------------------------------------------
C27 JET/PLUME SOURCE LOCATIONS, GEOMETRY AND ENTRAINMENT PARAMETERS
C
       ID: ID COUNTER FOR JET/PLUME
      ICAL: 1 ACTIVE, 0 BYPASS
      IQJP: I CELL INDEX OF JET/PLUME
      JQJP: J CELL INDEX OF JET/PLUME
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         KQJP:  K CELL INDEX OF JET/PLUME (DEFAULT, QJET=0 OR JET COMP DIVERGES)
         NPORT:  NUMBER OF IDENTIAL PORTS IN THIS CELL
         XJET:  LOCAL EAST JET LOCATION RELATIVE TO DISCHARGE CELL CENTER (M)
         YJET:  LOCAL NORTH JET LOCATION RELATIVE TO DISCHARGE CELL CENTER (M)
         ZJET:  ELEVATION OF DISCHARGE (M)
         PHJET:  VERTICAL JET ANGLE POSITIVE FROM HORIZONTAL (DEGREES)
         THJET:  HORIZONTAL JET ANGLE POS COUNTER CLOCKWISE FROM EAST (DEGREES)
         DJET:  DIAMETER OF DISCHARGE PORT (M)
         CFRD:  ADJUSTMENT FACTOR FOR FROUDE NUMBER
         DJPER:  ENTRAINMENT ERROR CRITERIA
C
C27 ID ICAL IQJP JQJP KQJP NPORT XJET  YJET  ZJET  PHJET THJET DJET  CFRD  DJPER
--------------------------------------------------------------------------------
C28 JET/PLUME SOLUTION CONTROL AND OUTPUT CONTROL PARAMETERS
C
         ID:  ID COUNTER FOR JET/PLUME
         NJEL:  MAXIMUM NUMBER OF ELEMENTS ALONG JET/PLUME LENGTH
         NJPMX:  MAXIMUM NUMBER OF ITERATIONS
         ISENT:  0 USE MAXIMUM OF SHEAR AND FORCED ENTRAINMENT
                 1 USE SUM OF SHEAR AND FORCED ENTRAINMENT
         ISTJP:  0 STOP AT SPECIFIED NUMBER OF ELEMENTS
                 1 STOP WHEN CENTERLINE PENETRATES BOTTOM OR SURFACE
                 2 STOP WITH BOUNDARY PENETRATES BOTTOM OR SURFACE
         NUDJP:  FREQUENCY FOR UPDATING JET/PLUME (NUMBER OF TIME STEPS)
         IOJP:  1 FOR FULL ASCII, 2 FOR COMPACT ASCII OUTPUT AT EACH UPDATE
                3 FOR FULL AND COMPACT ASCII OUTPUT, 4 FOR BINARY OUTPUT
         IPJP:  NUMBER OF SPATIAL PRINT/SAVE POINT IN VERTICAL
         ISDJP:  1 WRITE DIAGNOSTIS TO jplog___.out
         IUPJP:  I INDEX OF UPSTREAM WITHDRAWAL CELL IF ICAL=2
         JUPJP:  J INDEX OF UPSTREAM WITHDRAWAL CELL IF ICAL=2
         KUPJP:  K INDEX OF UPSTREAM WITHDRAWAL CELL IF ICAL=2
C
C28 ID  NJEL   NJPMX ISENT ISTJP NUDJP IOJP IPJP  ISDJP IUPJP JUPJP KUPJP
--------------------------------------------------------------------------------
C29 JET/PLUME SOURCE PARAMETERS AND DISCHARGE/CONCENTRATION SERIES IDS
C
         ID: ID COUNTER FOR JET/PLUME
         QQJP:  CONSTANT JET/PLUME FLOW RATE IN M*M*M/S
                 FOR ICAL = 1 OR 2  (FOR SINGLE PORT)
       NQSERJP:  ID NUMBER OF ASSOCIATED VOLUMN FLOW TIME SERIES
     NQWRSERJP:  ID NUMBER OF ASSOCIATED WITHDAWAL-RETURN TIME SERIES (ICAL=2)
       NSSERJP:  ID NUMBER OF ASSOCIATED SALINITY TIME SERIES
       NTSERJP:  ID NUMBER OF ASSOCIATED TEMPERATURE TIME SERIES
       NDSERJP:  ID NUMBER OF ASSOCIATED DYE CONC TIME SERIES
      NSFSERJP:  ID NUMBER OF ASSOCIATED SHELL FISH LARVAE RELEASE TIME SERIES
      NTXSERJP:  ID NUMBER OF ASSOCIATED TOXIC CONTAMINANT CONC TIME SERIES
      NSDSERJP:  ID NUMBER OF ASSOCIATED COHEASIVE SEDIMENT CONC TIME SERIES
      NSNSERJP:  ID NUMBER OF ASSOCIATED NONCOHEASIVE SED CONC TIME SERIES
C
C29  ID   QQJP   NQSERJP NQWRSERJP  NS-  NT-  ND-  NSF-  NTX-  NSD-  NSN-
--------------------------------------------------------------------------------
C30 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT JET/PLUME SOURCES
C
         SAL:  SALT CONCENTRATION CORRESPONDING TO INFLOW ABOVE
         TEM:  TEMPERATURE CORRESPONDING TO INFLOW ABOVE
         DYE:  DYE CONCENTRATION CORRESPONDING TO INFLOW ABOVE
         SFL:  SHELL FISH LARVAE CONCENTRATION CORRESPONDING TO INFLOW ABOVE
         TOX:  NTOX TOXIC CONTAMINANT CONCENTRATIONS CORRESPONDING TO
              INFLOW ABOVE  WRITTEN AS TOXC(N), N=1,NTOX A SINGLE DEFAULT
              VALUE IS REQUIRED EVEN IF TOXIC TRANSPORT IS NOT ACTIVE
C
C30 SAL TEM DYE SFL TOX1-20
--------------------------------------------------------------------------------
C31 TIME CONSTANT INFLOW CONCENTRATIONS FOR TIME CONSTANT JET/PLUME SOURCES
C
         SED:  NSED COHESIVE SEDIMENT CONCENTRATIONS CORRESPONDING TO
```

```
          INFLOW ABOVE  WRITTEN AS SEDC(N), N=1,NSED. I.E., THE FIRST
          NSED VALUES ARE COHESIVE A SINGLE DEFAULT VALUE IS REQUIRED
          EVEN IF COHESIVE SEDIMENT TRANSPORT IS INACTIVE
       SND: NSND NON-COHESIVE SEDIMENT CONCENTRATIONS CORRESPONDING TO
          INFLOW ABOVE  WRITTEN AS SND(N), N=1,NSND. I.E., THE LAST
          NSND VALUES ARE NON-COHESIVE. A SINGLE DEFAULT VALUE IS
          REQUIRED EVEN IF NON-COHESIVE SEDIMENT TRANSPORT IS INACTIVE
C
C31 SED1  SND1  SND2  SND3
-------------------------------------------------------------------------------
C32 SURFACE ELEV OR PRESSURE DEPENDENT FLOW INFORMATION
C
       IQCTLU:  I INDEX OF UPSTREAM OR WITHDRAWAL CELL
       JQCTLU:  J INDEX OF UPSTREAM OR WITHDRAWAL CELL
       IQCTLD:  I INDEX OF DOWNSTREAM OR RETURN CELL
       JQCTLD:  J INDEX OF DOWNSTREAM OR RETURN CELL
       NQCTYP:  FLOW CONTROL TYPE
                   =-1  RATING CURVED FLOW AS FUNCTION UPSTREAM DEPTH
              = 0  HYDRAULIC STRUCTURE: INSTANT FLOW DRIVEN BY ELEVATION
                 OR PRESSURE DIFFERCENCE TABLE
              = 1  ACCELERATING FLOW THROUGH TIDAL INLET
       NQCTLQ:  ID NUMBER OF CONTROL CHARACTERIZATION TABLE
       NQCMUL:  MULTIPLIER SWITCH FOR FLOWS FROM UPSTREAM CELL
              = 0  MULT BY 1. FOR CONTROL TABLE IN (L*L*L/T)
              = 1  MULT BY DY FOR CONTROL TABLE IN (L*L/T) ON U FACE
              = 2  MULT BY DX FOR CONTROL TABLE IN (L*L/T) ON V FACE
              = 3  MULT BY DX+DY FOR CONTROL TABLE IN (L*L/T) ON U&V FACES
       NQCMFU:  IF NON ZERO ACCOUNT FOR FLOW MOMENTUM FLUX IN UPSTREAM CELL
              = 1  MOMENTUM FLUX ON NEG U FACE
              = 2  MOMENTUM FLUX ON NEG V FACE
              = 3  MOMENTUM FLUX ON POS U FACE
              = 4  MOMENTUM FLUX ON POS V FACE
       NQCMFD:  IF NON ZERO ACCOUNT FOR FLOW MOMENTUM FLUX IN DOWNSTREAM CELL
              = 1  MOMENTUM FLUX ON NEG U FACE
              = 2  MOMENTUM FLUX ON NEG V FACE
              = 3  MOMENTUM FLUX ON POS U FACE
              = 4  MOMENTUM FLUX ON POS V FACE
       BQCMFU:  UPSTREAM MOMENTUM FLUX WIDTH (M)
       BQCMFD:  DOWNSTREAM MOMENTUM FLUX WIDTH (M)
C
C32 IQCTLU JQCTLU IQCTLD JQCTLD NQCTYP NQCTLQ NQCMUL NQC_U NQC_D BQC_U  BQC_D
     6   565   0    0    0    1    0    0    0    0    0
-------------------------------------------------------------------------------
C33 FLOW WITHDRAWAL, HEAT OR MATERIAL ADDITION, AND RETURN DATA
C
       IWRU:    I INDEX OF UPSTREAM OR WITHDRAWAL CELL
       JWRU:    J INDEX OF UPSTREAM OR WITHDRAWAL CELL
       KWRU:    K INDEX OF UPSTREAM OR WITHDRAWAL LAYER
       IWRD:    I INDEX OF DOWNSTREAM OR RETURN CELL
       JWRD:    J INDEX OF DOWNSTREAM OR RETURN CELL
       KWRD:    J INDEX OF DOWNSTREAM OR RETURN LAYER
       QWRE:     CONSTANT VOLUME FLOW RATE FROM WITHDRAWAL TO RETURN
       NQWRSERQ: ID NUMBER OF ASSOCIATED VOLUMN WITHDRAWAL-RETURN FLOW AND
             CONCENTRATION RISE TIME SERIES
       NQWRMFU:  IF NON ZERO ACCOUNT FOR WITHDRAWAL FLOW MOMENTUM FLUX
              = 1  MOMENTUM FLUX ON NEG U FACE
              = 2  MOMENTUM FLUX ON NEG V FACE
              = 3  MOMENTUM FLUX ON POS U FACE
              = 4  MOMENTUM FLUX ON POS V FACE
       NQWRMFD:  IF NON ZERO ACCOUNT FOR RETURN FLOW MOMENTUM FLUX
              = 1  MOMENTUM FLUX ON NEG U FACE
              = 2  MOMENTUM FLUX ON NEG V FACE
              = 3  MOMENTUM FLUX ON POS U FACE
              = 4  MOMENTUM FLUX ON POS V FACE
       BQWRMFU: UPSTREAM MOMENTUM FLUX WIDTH (M)
       BQWRMFD: UPSTREAM MOMENTUM FLUX WIDTH (M)
```

ANGWRMFD: ANGLE FOR HORIZONTAL FOR RETURN FLOW MOMENTUM FLUX
C
C33 IWRU JWRU KWRU IWRD JCWRD KWRD QWRE NQW_RQ NQWR_U NQWR_D BQWR_U BQWR_D AN_D

C34 TIME CONSTANT WITHDRAWAL AND RETURN CONCENTRATION RISES
C
    SAL: SALTINITY RISE
    TEM: TEMPERATURE RISE
    DYE: DYE CONCENTRATION RISE
    SFL: SHELLFISH LARVAE CONCENTRATION RISE
    TOX#: NTOX TOXIC CONTAMINANT CONCENTRATION RISES
C
C34 SALT TEMP DYEC SFLC TOX1

C35 TIME CONSTANT WITHDRAWAL AND RETURN CONCENTRATION RISES
C
    SED#:   NSEDC COHESIVE SEDIMENT CONCENTRATION RISE
    SND#:   NSEDN NONCOHESIVE SEDIMENT CONCENTRATION RISE
C
C35 SED1 SND1 SND2

C36 SEDIMENT INITIALIZATION AND WATER COLUMN/BED REPRESENTATION OPTIONS
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) ARE 0
C
  ISEDINT: 0 FOR CONSTANT INITIAL CONDITIONS
        1 FOR SPATIALLY VARIABLE WATER COLUMN INITIAL CONDITIONS
          FROM SEDW.INP AND SNDW.INP
        2 FOR SPATIALLY VARIABLE BED INITIAL CONDITIONS
          FROM SEDB.INP AND SNDB.INP
        3 FOR SPATIALLY VARIABLE WATER COL AND BED INITIAL CONDITIONS
  ISEDBINT: 0 FOR SPATIALLY VARYING BED INITIAL CONDITIONS IN MASS/AREA
        1 FOR SPATIALLY VARYING BED INITIAL CONDITIONS IN MASS FRACTION
          OF TOTAL SEDIMENT MASS (REQUIRES BED LAYER THICKNESS
          FILE BEDLAY.INP)
  ISEDWC: 0 COHESIVE SED WC/BED EXCHANGE BASED ON BOTTOM LAYER CONDITIONS
        1 COHESIVE SED WC/BED EXCHANGE BASED ON WAVE/CURRENT/SEDIMENT
          BOUNDARY LAYERS EMBEDDED IN BOTTOM LAYER
  ISMUD: 1 INCLUDE COHESIVE FLUID MUD VISCOUS EFFECTS USING EFDC
          FUNCTION CSEDVIS(SEDT)
  ISNDWC: 0 NONCOH SED WC/BED EXCHANGE BASED ON BOTTOM LAYER CONDITIONS
        1 NONCOH SED WC/BED EXCHANGE BASED ON WAVE/CURRENT/SEDIMENT
          BOUNDARY LAYERS EMBEDDED IN BOTTOM LAYER
  ISEDVW: 0 FOR CONSTANT OR SIMPLE CONCENTRATION DEPENDENT
          COHESIVE SEDIMENT SETTLING VELOCITY
        >1 CONCENTRATION AND/OR SHEAR/TURBULENCE DEPENDENT COHESIVE
          SEDIMENT SETTLING VELOCITY. VALUE INDICATES OPTION TO BE USED
          IN EFDC FUNCTION CSEDSET(SED,SHEAR,ISEDVWC)
        1 HUANG AND METHA - LAKE OKEECHOBEE
        2 SHRESTA AND ORLOB - FOR KRONES SAN FRANCISCO BAY DATA
        3 ZIEGLER AND NESBIT - FRESH WATER
        98 LICK FLOCCULATOIN
        99 LICK FLOCCULATION WITH FLOC DIAMETER ADVECTION
  ISNDVW: 0 USE CONSTANT SPECIFIED NON-COHESIVE SED SETTLING VELOCITIES
          OR CALCULATE FOR CLASS DIAMETER IS SPECIFIED VALUE IS NEG
        >1 FOLLOW OPTION 0 PROCEDURE BUT APPLY HINDERED SETTLING
          CORRECTION. VALUE INDICATES OPTION TO BE USED WITH EFDC
          FUNCTION CSNDSET(SND,SDEN,ISNDVW) VALUE OF ISNDVW INDICATES
          EXPONENTIAL IN CORRECT (1-SDEN(NS)*SND(NS)**ISNDVW
    KB: MAXIMUM NUMBER OF BED LAYERS (EXCLUDING ACTIVE LAYER)
  ISDTXBUG: 1 TO ACTIVATE SEDIMENT AND TOXICS DIAGNOSTICS
C
C36 ISEDINT ISEDBINT ISEDWC ISMUD ISNDWC ISEDVW ISNDVW KB   ISDTXBUG

C36a SEDIMENT INITIALIZATION AND WATER COLUMN/BED REPRESENTATION OPTIONS
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) ARE 0
C

ISBEDSTR: 0 USE HYDRODYNAMIC MODEL STRESS FOR SEDIMENT TRANSPORT
        1 SEPARATE GRAIN STRESS FORM TOTAL IN COH AND NONCOH COMPONENTS
        2 SEPARATE GRAIN STRESS FROM TOTAL APPLY TO COH AND NONCOH SEDS
        3 USE INDEPENDENT LOG LAW ROUGHNESS HEIGHT FOR SEDIMENT TRANSPORT
          READ FROM FILE SEDROUGH.INP
        4 SEPARATE GRAIN STRESS FROM TOTAL USING COH/NONCOH WEIGHTED
          ROUGHNESS AND LOG LAW RESISTANCE (IMPLEMENTED 5/31/05)
        5 SEPARATE GRAIN STRESS FROM TOTAL USING COH/NONCOH WEIGHTED
          ROUGHNESS AND POWER LAW RESISTANCE (IMPLEMENTED 5/31/05)
ISBSDIAM: 0 USE D50 DIAMETER FOR NONCOHESIVE ROUGHNESS
        1 USE 2*D50 FOR NONCOHESIVE ROUGHNESS
        2 USE D90 FOR NONCOHESIVE ROUGHNESS
        3 USE 2*D90 FOR NONCOHESIVE ROUGHNESS
ISBSDFUF: 1 CORRECT GRAIN STRESS PARTITIONING FOR NONUNIFORM FLOW EFFECTS
        CAN NOW BE USED FOR ISBEDSTR=4 AND 5
COEFTSBL: COEFFICIENT SPECIFYING THE HYDRODYNAMIC SMOOTHNESS OF
        TURBULENT BOUNDARY LAYER OVER COEHESIVE BED IN TERMS OF
        EQUIVALENT GRAIN SIZE FOR COHESIVE GRAIN STRESS
        CALCULATION, FULLY SMOOTH = 4, FULL ROUGH = 100.
        NOT USED FOR ISBEDSTR=4 AND 5
VISMUDST: KINEMATIC VISCOSITY TO USE IN DETERMINING COHESIVE GRAIN STRESS
ISBKERO: 1 FOR BANK EROSION SPECIFIED BY EXTERNAL TIME SERIES
        2 FOR BANK EROSION INTERNALLY CALCULATED BY STABILITY ANALYSIS

C36a ISBEDSTR ISBSDIAM ISBSDFUF COEFTSBL VISMUDST   ISBKERO

C36B SEDIMENT INITIALIZATION AND WATER COLUMN/BED REPRESENTATION OPTIONS
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) ARE 0
C
  ISEDAL: 1 TO ACTIVATE STATIONARY COHESIVE MUD ACTIVE LAYER
  ISNDAL: 1 TO ACTIVATE NON-COHESIVE ARMORING EFFECTS
        2 SAME AS 1 WITH ACTIVE-PARENT LAYER FORMULATION
  IALTYP; 0 CONSTANT THICKNESS ARMORING LAYER
        1 CONSTANT TOTAL SEDIMENT MASS ARMORING LAYER
  IALSTUP: 1 CREATE ARMORING LAYER FROM INITIAL TOP LAYER AT START UP
  ISEDEFF: 1 MODIFY NONCOHESIVE RESUSPENSION TO ACCOUNT FOR COHESIVE EFFECTS
          USING MULTIPLICATION FACTOR: EXP(-COEHEFF*FRACTION COHESIVE)
        2 MODIFY NONCOHESIVE CRITICAL STRESS TO ACCOUNT FOR COHESIVE EFFECTS
          USING MULT FACTOR: 1+(COEHEFF2-1)*(1-EXP(-COEHEFF*FRACTION COHESIVE))
  HBEDAL: ACTIVE ARMORING LAYER THICKNESS
  COEHEFF: COHESIVE EFFECTS COEFFICIENT
  COEHEFF2: COHESIVE EFFECTS COEFFICIENT
          1
C36B ISEDAL ISNDAL IALTYP IALSTUP ISEDEFF HBEDAL   COEHEFF COEHEFF2

C37 BED MECHANICAL PROPERTIES PARAMETER SET 1
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) ARE 0
C
  ISEDDT: NUMBER OF SED/TOX BED PROCESSES STEPS PER HYDRO/WC TRANS STEPS
  IBMECH: 0 TIME INVARIANT CONSTANT BED MECHANICAL PROPERITES
        1 SIMPLE CONSOLIDATION CALCULATION WITH CONSTANT COEFFICIENTS
        2 SIMPLE CONSOLIDATION WITH VARIABLE COEFFICIENTS DETERMINED
          EFDC FUNCTIONS CSEDCON1,2,3(IBMECH)
        3 COMPLEX CONSOLIDATION WITH VARIABLE COEFFICIENTS DETERMINED
          EFDC FUNCTIONS CSEDCON1,2,3(IBMECH). IBMECH > 0 SETS THE
          C38 PARAMETER ISEDBINT=1 AND REQUIRES INITIAL CONDITIONS
          FILES BEDLAY.INP, BEDBDN.INP AND BEDDDN.IN
        9 TYPE OF CONSOLIDATION VARIES BY CELL WITH IBMECH FOR EACH
          DEFINED IN INPUT FILE CONSOLMAP.INP
  IMORPH: 0 CONSTANT BED MORPHOLOGY (IBMECH=0, ONLY)
        1 ACTIVE BED MORPHOLOGY: NO WATER ENTRAIN/EXPULSION EFFECTS
        2 ACTIVE BED MORPHOLOGY: WITH WATER ENTRAIN/EXPULSION EFFECTS
  HBEDMAX: TOP BED LAYER THICKNESS (M) AT WHICH NEW LAYER IS ADDED OR IF
        KBT(I,J)=KB, NEW LAYER ADDED AND LOWEST TWO LAYERS COMBINED
  BEDPORC: CONSTANT BED POROSITY (IBMECH=0, OR NSED=0)
        ALSO USED AS POROSITY OF DEPOSITIN NON-COHESIVE SEDIMENT

SEDMDMX: MAXIMUM FLUID MUD COHESIVE SEDIMENT CONCENTRATION (MG/L)
SEDMDMN: MINIMUM FLUID MUD COHESIVE SEDIMENT CONCENTRATION (MG/L)
SEDVDRD: VOID RATIO OF DEPOSITING COHESIVE SEDIMENT
SEDVDRM: MINIMUM COHESIVE SEDIMENT BED VOID RATIO (IBMECH > 0)
SEDVDRT: BED CONSOLIDATION RATED CONSTANT (1/SEC) (IBMECH = 1,2)
       GT 0 CONSOLIDATE OVER TIME TO SEDVDRM
       EQ 0 CONSOLIDATE INSTANTANEOUSLY TO SEDVDRM
       LT 0 CONSOLIDATE TO INITIAL VOID RATIOS
C
C37 ISEDDT IBMECH IMORPH HBEDMAX BEDPORC SEDMDMX SEDMDMN SEDVDRD SEDVDRM SEDVDRT

C38 BED MECHANICAL PROPERTIES PARAMETER SET 2 (CONSOLIDATION COEFFICIENTS)
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) ARE 0
C
  IBMECHK: 0 FOR HYDRAULIC CONDUCTIVITY, K, FUNCTION K=KO*EXP((E-EO)/EK)
      1 FOR HYD COND/(1+VOID RATIO),K', FUNCTION K'=KO'*EXP((E-EO)/EK)
  BMECH1:   REFERENCE EFFECTIVE STRESS/WATER SPECIFIC WEIGHT, SEO (M)
      IF BMECH1<0 USE INTERNAL FUNCTION, BMECH1,BMECH2,BMECH3 NOT USED
  BMECH2:   REFERENCE VOID RATIO FOR EFFECTIVE STRESS FUNCTION, EO
  BMECH3:   VOID RATIO RATE TERM ES IN SE=SEO*EXP(-(E-EO)/ES)
  BMECH4:   REFERENCE HYDRAULIC CONDUCTIVITY, KO (M/S)
      IF BMECH4<0 USE INTERNAL FUNCTION, BMECH1,BMECH2,BMECH3 NOT USED
  BMECH5:   REFERENCE VOID RATIO FOR HYDRAULIC CONDUCTIVITY, EO
  BMECH6:   VOID RATIO RATE TERM EK IN (K OR K')=(KO OR KO')*EXP((E-EO)/EK)
C   1.35 1.033   1.033   0.0607 3.8   3.8
C38 IBMECHK BMECH1 BMECH2 BMECH3   BMECH4 BMECH5   BMECH6

C39 COHESIVE SEDIMENT PARAMETER SET 1 REPEAT DATA LINE NSED TIMES
C   DATA REQUIRED EVEN IF ISTRAN(6) AND ISTRAN(7) ARE 0
C
  SEDO: CONSTANT INITIAL COHESIVE SEDIMENT CONC IN WATER COLUMN
     (MG/LITER=GM/M**3)
  SEDBO: CONSTANT INITIAL COHESIVE SEDIMENT IN BED PER UNIT AREA
     (GM/SQ METER) IE 1CM THICKNESS BED WITH SSG=2.5 AND
     N=.6,.5 GIVES SEDBO 1.E4, 1.25E4
  SDEN: SEDIMENT SPEC VOLUME (IE 1/2.25E6 M**3/GM)
  SSG: SEDIMENT SPECIFIC GRAVITY
  WSEDO: CONSTANT OR REFERENCE SEDIMENT SETTLING VELOCITY
     IN FORMULA WSED=WSEDO*((SED/SEDSN)**SEXP)
  SEDSN: NOT USED
  SEXP: NOT USED
  TAUD: BOUNDARY STRESS BELOW WHICH DEPOSITION TAKES PLACE ACCORDING
     TO (TAUD-TAU)/TAUD (M**2/S**2)
  ISEDSCOR: 1 TO CORRECT BOTTOM LAYER CONCENTRATION TO NEAR BED CONC
  ISPROBDEP: 0 KRONE PROBABILITY OF DEPOSTION USING COHESIVE GRAIN STRESS
      1 KRONE PROBABILITY OF DEPOSTION USING TOTAL BED STRESS
      2 PARTHEN PROBABILITY OF DEPOSTION USING COHESIVE GRAIN STRESS
      3 PARTHEN PROBABILITY OF DEPOSTION USING TOTAL BED STRESS
        0.00005
C39 SEDO SEDBO SDEN   SSG   WSEDO SEDSN SEXP TAUD   ISEDSCOR ISPROBDEP

C40 COHESIVE SEDIMENT PARAMETER SET 2 REPEAT DATA LINE NSED TIMES
C   DATA REQUIRED EVEN IT ISTRAN(6) AND ISTRAN(7) ARE 0
C
  IWRSP: 0 USE RESUSPENSION RATE AND CRITICAL STRESS BASED ON PARAMETERS
     ON THIS DATA LINE
      >1 USE BED PROPERTIES DEPENDEDNT RESUSPENSION RATE AND CRITICAL
      STRESS GIVEN BY EFDC FUNCTIONS CSEDRESS AND CSEDTAUS
      FUNCTION ARGUMENSTS ARE (BDENBED,IWRSP)
      1 HWANG AND METHA - LAKE OKEECHOBEE
      2 HAMRICK'S MODIFICATION OF SANFORD AND MAA USING ACTUAL VOID RATIO
      3 SAME AS 2 EXCEPT VOID RATIO OF COHESIVE SEDIMENT FRACTION IS USED
      4 SEDFLUME WITHOUT CRITICAL STRESS
      5 SEDFLUME WITH CRITICAL STRESS
     >99 SITE SPECIFIC
  IWRSPB:0 NO BULK EROSION

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                1 USE BULK EORSION CRITICAL STRESS AND RATE IN FUNCTIONS
                  CSEDTAUB AND CSEDRESSB
      WRSPO:   REF SURFACE EROSION  RATE IN FORMULA
               WRSP=WRSP0*( ((TAU-TAUR)/TAUN)**TEX ) (GM/M**2-SEC)
      TAUR:    BOUNDARY STRESS ABOVE WHICH SURFACE EROSION OCCURS (M/S)**2
      TAUN:    NORMALIZING STRESS (EQUAL TO TAUR FOR COHESIVE SED TRANS)
      TEXP:    EXPONENTIAL (COH SED)
      VDRRSPO: REFERENCE VOID RATIO FOR CRITICAL STRESS AND RESUSPENSION RATE
               IWRSP=2,3
      COSEDHID: COHESIVE SEDIMENT RESUSPENSION HIDING FACTOR TO REDUCE COHESIVE
                RESUSPENSION BY FACTOR = (COHESIVE FRACTION OF SEDIMENT)**COSEDHID
C
C40 IWRSP IWRSPB WRSPO    TAUR    TAUN    TEXP VDRRSPO COSEDHID
-------------------------------------------------------------------------------
C41 NONCOHESIVE SEDIMENT PARAMETER SET 1 REPEAT DATA LINE NSND TIMES
C   DATA REQUIRED EVEN IT ISTRAN(6) AND ISTRAN(7) ARE 0
C
      SNDO:   CONSTANT INITIAL NONCOHESIVE SEDIMENT CONC IN WATER COLUMN
              (mg/liter=gm/m**3)
      SNDBO:  CONSTANT INITIAL NONCOHESIVE SEDIMENT IN BED PER UNIT AREA
              (gm/sq meter)  IE 1CM THICKNESS BED WITH SSG=2.5 AND
              N=.6,.5 GIVES SNDBO 1.E4, 1.25E4
      SDEN:   SEDIMENT SPEC VOLUME (IE 1/2.65E6 m**3/gm)
      SSG:    SEDIMENT SPECIFIC GRAVITY
      SNDDIA: REPRESENTATIVE DIAMETER OF SEDIMENT CLASS
      WSNDO:  CONSTANT OR REFERENCE SEDIMENT SETTLING VELOCITY
              IF WSNDO < 0, SETTLING VELOCITY INTERNALLY COMPUTED
      SNDN:   MAX MASS/TOT VOLUME IN BED (NONCOHESIVE SED TRANS) (gm/m**3)
      SEXP:   DIMENSIONLESS RESUSPENSION PARAMETER GAMMA ZERO
      TAUD:   DUNE BREAK POINT STRESS  (m/s)**2
    ISNDSCOR: 1 TO CORRECT BOTTOM LAYER CONCENTRATION TO NEAR BED CONC
C          3.77E-5 2.65   1.2E-3
C41 SNDO SNDBO  SDEN   SSG   SNDDIA WSNDO SNDN  SEXP   TAUD  ISNDSCOR
-------------------------------------------------------------------------------
C42 NON-COHESIVE SEDIMENT PARAMETER SET 2 REPEAT DATA LINE NSND TIMES
C   DATA REQUIRED EVEN IT ISTRAN(6) AND ISTRAN(7) ARE 0
C
    ISNDEQ: >1 CALCULATE ABOVE BED REFERENCE NON-COHESIVE SEDIMENT
            EQUILIBRIUM CONCENTRATION USING EFDC FUNCTION
            CSNDEQC(SNDDIA,SSG,WS,TAUR,TAUB,SIGPHI,SNDDMX,IOTP)
            WHICH IMPLEMENT FORMULATIONS OF
            1 GARCIA AND PARKER
            2 SMITH AND MCLEAN
            3 VAN RIJN
            4 SEDFLUME WITHOUT CRITICAL STRESS
            5 SEDFLUME WITH CRITICAL STRESS
    ISBDLD: 0 BED LOAD PHI FUNCTION IS CONSTANT,MEYER-PETER & MUELLER,BAGNOLD
            1 VAN RIJN PHI FUNCTION
            2 MODIFIED ENGULAND-HANSEN
            3 WU, WANG, AND JIA
            4 SEDFLUME WITHOUT CRITICAL STRESS
            5 SEDFLUME WITH CRITICAL STRESS
     TAUR:   CRITICAL STRESS IN (m/s)**2
             NOTE: IF TAUR < 0, THEN TAUR, TAUN, AND TEXP ARE INTERNALLY
             COMPUTED USING VAN RIJN'S FORMULAS
     TAUN:   EQUAL TO TAUR FOR NON-COHESIVE SED TRANS
    TCSHIELDS:  CRITICAL SHIELDS STRESS (DIMENSIONLESS)
     ISLTAUC: 1 TO IMPLEMENT SUSP LOAD ONLY WHEN STRESS EXCEEDS TAUC FOR EACH GRAIN
              2 TO IMPLEMENT SUSP LOAD ONLY WHEN STRESS EXCEEDS TAUCD50
              3 TO USE TAUC FOR NONUNIFORM BEDS, THESE APPLY ONLY TO RESUSPENSION
                FORMULAS NOT EXPLICITLY CONTAINING CRITICAL SHIELDS STRESS SUCH AS G-P
     IBLTAUC: 1 TO IMPLEMENT BEDLOAD ONLY WHEN STRESS EXCEEDS TAUC FOR EACH GRAIN
              2 TO IMPLEMENT BEDLOAD ONLY WHEN STRESS EXCEEDS TAUCD50
              3 TO USE TAUC FOR NONUNIFORM BEDS, THESE APPLY ONLY TO BED LOAD
                FORMULAS NOT EXPLICITLY CONTAINING CRITICAL SHIELDS STRESS SUCH AS E-H
     IROUSE:  0 USE TOTAL STRESS FOR CALCULATING ROUSE NUMBER
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                      1 USE GRAIN STRESS FOR ROUSE NUMBER
        ISNDM1:  0 SET BOTH BEDLOAD AND SUSPENDED LOAD FRACTIONS TO 1.0
                 1 SET BEDLOAD FRACTION TO 1. USE BINARY RELATIONSHIP FOR SUSPENDED
                 2 SET BEDLOAD FRACTION TO 1, USE LINEAR RELATIONSHIP FOR SUSPENDED
                 3 USE BINARY RELATIONSHIP FOR BEDLOAD AND SUSPENDED LOAD
                 4 USE LINEAR RELATIONSHIP FOR BEDLOAD AND SUSPENDED LOAD
        ISNDM2:  0 USE TOTAL SHEAR VELOCITY IN USTAR/WSET RATIO
                 1 USE GRAIN SHEAR VELOCITY IN USTAR/WSET RATIO
        RSNDM:     VALUE OF USTAR/WSET FOR BINARY SWITHCH BETWEEN BEDLOAD AND SUSPENDED
LOAD
C                           1    1    0
C42  ISNDEQ ISBDLD  TAUR   TAUN   TCSHIELDS ISLTAUC IBLTAUC IROUSE ISNDM1  ISNDM2  RSNDM
-----------------------------------------------------------------------------
C42A NON-COHESIVE SEDIMENT PARAMETER SET 3 (BED LOAD FORMULA PARAMETERS)
C    DATA REQUIRED EVEN IT ISTRAN(6) AND ISTRAN(7) ARE 0
C
     IBEDLD:  0 DISABLE BEDLOAD
             1 ACTIVATE BEDLOAD OPTION.  MUST USE SEDBLBC.INP
     SBDLDA:ALPHA EXPONENTIAL FOR BL FORMULA,MPM=1.5,BAG=1,VR=2.1,EH=2.5,WWJ=2.2
     SBDLDB:BETA EXPONENTIAL FOR BED LOAD FORMULA,BAG=1.0,MPM=VR=EH=WWJ=0.0
     SBDLDG1:GAMMA1 CONSTANT FOR BED LOAD FORMULA,BAG=MPM=VR=EH=WWJ=1.0
     SBDLDG2:GAMMA2 CONSTANT FOR BED LOAD FORMULA,EH=0.0,BAG=MPM=VR=WWJ=1.0
     SBDLDG3:GAMMA3 CONSTANT FOR BED LOAD FORMULA,BAG=MPM=VR=EH=WWJ=1.0
     SBDLDG4:GAMMA4 CONSTANT FOR BED LOAD FORMULA,BAG=1.0,MPM=VR=EH=WWJ=0.0
     SBDLDP:CONSTANT PHI FOR BED LOADFORMULA,BAG=CONST,MPM=7.6,VR=EH=WWJ=INTERNALY
     ISBLFUC: BED LOAD FACE FLUX , 0 FOR DOWN WIND PROJECTION,1 FOR DOWN WIND
            WITH CORNER CORRECTION,2 FOR CENTERED AVERAGING
     BLBSNT: ADVERSE BED SLOOP (POSITIVE VALUE) ACROSS A CELL FACE ABOVE
            WHICH NO BED LOAD TRANSPORT CAN OCCUR.  NOT ACTIVE FOR BLBSNT=0.0
C    1
C42a IBEDLD SBDLDA SBDLDB SBDLDG1 SBDLDG2 SBDLDG3 SBDLDG4 SBDLDP ISBLFUC BLBSNT
-----------------------------------------------------------------
C43 TOXIC CONTAMINANT INITIAL CONDITIONS AND PARAMETERS
C   USER MAY CHANGE UNITS OF WATER AND SED PHASE TOX CONCENTRATION
C   AND PARTIATION COEFFICIENT ON C44 - C46 BUT CONSISTENT UNITS MUST
C   MUST BE USED FOR MEANINGFUL RESULTS
C   DATA REQUIRED EVEN IT ISTRAN(5) IS 0
C
     NTOXN:   TOXIC CONTAMINANT NUMBER ID (1 LINE OF DATA BY DEFAULT)
     ITXINT:  0 FOR SPATIALLY CONSTANT WATER COL AND BED INITIAL CONDITIONS
              1 FOR SPATIALLY VARIABLE WATER COLUMN INITIAL CONDITIONS
              2 FOR SPATIALLY VARIABLE BED INITIAL CONDITIONS
              3 FOR SPATIALLY VARIABLE WATER COL AND BED INITIAL CONDITION
     ITXBDUT:  SET TO 0 FOR CONST INITIAL BED GIVEN BY TOTAL TOX (ugm/litr)
               SET TO 1 FOR CONST INITIAL BED GIVEN BY
                SORBED MASS TOX/MASS SED(mg/kg)
     TOXINTW:  INIT WATER COLUNM TOT TOXIC VARIABLE CONCENTRATION (ugm/litr)
     TOXINTB:  INIT SED BED TOXIC CONC SEE ITXBDUT
     RKTOXW:   FIRST ORDER WATER COL DECAY RATE FOR TOX VARIABLE IN 1/SEC
     TKTOXW:   REF TEMP FOR 1ST ORDER WATER COL DECAY DEG C
     RKTOXB:   FIRST ORDER SED BED DECAY RATE FOR TOX VARIABLE IN 1/SEC
     TKTOXB:   REF TEMP FOR 1ST ORDER SED BED DECAY DEG C
C              ck blw kevin uses 6.0
C43 NTOXN ITXINT ITXBDUT TOXINTW TOXINTB RKTOXW TKTOXW RKTOXB TRTOXB COMMENTS
-----------------------------------------------------------------
C44 ADDITIONAL TOXIC CONTAMINANT PARAMETERS
C   DATA REQUIRED EVEN IT ISTRAN(5) IS 0
C
    NTOXN: TOXIC CONTAMINANT NUMBER ID (1 LINE OF DATA BY DEFAULT)
    ISTOC: 1 FOR DISS AND PART ORGANIC CARBON SORPTION
           2 FOR DISS ORGANIC CARBON SORPTION AND POC FRACTIONALLY
            DISTRIBUTED TO INORGANIC SEDIMENT CLASSES
           3 FOR NO DISS ORGANIC CARBON SORPTION AND POC FRACTIONALLY
            DISTRIBUTED TO INORGANIC SEDIMENT CLASSES
    VOLTOX:   WATER SURFACE VOLITIALIZATION RATE MULTIPLIER (0. OR 1.)
    RMOLTX:   MOLECULAR WEIGHT FOR DETERMINING VOLATILIZATION RATE
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RKTOXP: REFERENCE PHOTOLOYSIS DECAY RATE 1/SEC
    SKTOXP: REFERENCE SOLAR RADIATION FOR PHOTOLOYSIS (WATTS/M**2)
    DIFTOX: DIFFUSION COEFF FOR TOXICANT IN SED BED PORE WATER (M**2/S)
    DIFTOXS: TRANSFER COEFF FOR TOXICANT BETWEEN WATER COLUMN AND
            PORE WATER IN TOP LAYER OF THE BED
            > 0.0 INTERPRET AS DIFFUSION COEFFICIENT(M**2/S)
            < 0.0 INTERPRET AS FLUX VELOCITY (M/S)
    PDIFTOX: PARTICLE MIXING DIFFUSION COEFF FOR TOXICANT IN SED BED (M**2/S)
        (if negative use zonal files PARTMIX.INP and PMXMAP.INP)
    DPDIFTOX: DEPTH IN BED OVER WHICH PARTICLE MIXING IS ACTIVE (M)
C
C44 NTOXN ISTOC VOLTOX RMOLTX RKTOXP SKTOXP DIFTOX DIFTOXS PDIFTOX DPDIFTOX COMMENTS

C44A POREWATER TOXICS ADVECTION AND DIFFUSION SOLUTION SWITCHES
C   AND DIAGNOSTIC/MASS BALANCE FLUX SWITHCHES
C
    IADTOXDP: 0 FOR STANDARD SINGLE PRECISION SOLUTION
            1 FOR DOUBLE PRECISION SOLUTION
    IADTOXCOR: 0 NOT CORRECTION OF SINGLE PRECISION SOLUTION
            1 MASS WEIGHTED CORRECTION OF SINGLE PRECISION SOLUTION
            2 MASS CHANGE WEIGHTED CORRECTION OF SINGLE PRECISION SOLUTION
    ISTOXALL   1 TO ACTIVATE ACCUMULATION OF TOXIC FLUXES
    NSTOXALL   NUMBER OF WRITES OF ACCUMULATED FLUXES PER REFERENCE TIME PERIOD
C
C44A IADTOXDP IADTOXCOR   ISTOXALL   NSTOXALL

C45 TOXIC CONTAMINANT SEDIMENT INTERACTION PARAMETERS
C   2 LINES OF DATA REQUIRED EVEN IT ISTRAN(5) IS 0
C
    NTOXC: TOXIC CONTAMINANT NUMBER ID. NSEDC+NSEDN LINES OF DATA
        FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
  NSEDN/NSNDN: FIRST NSED LINES COHESIVE, NEXT NSND LINES NON-COHESIVE.
        REPEATED FOR EACH CONTAMINANT
    ITXPARW: EQUAL 1 FOR SOLIDS DEPENDENT PARTITIONING (WC) GIVEN BY
        TOXPAR=PARO*(CSED**CONPAR)
   TOXPARW: WATER COLUMN PARO (ITXPARW=1) OR EQUIL TOX CON PART COEFF BETWEEN
        EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (liters/mg)
    CONPARW: EXPONENT IN TOXPAR=PARO*(CSED**CONPARW) IF ITXPARW=1
    ITXPARB: EQUAL 1 FOR SOLIDS DEPENDENT PARTITIONING (BED)
    TOXPARB: SEDIMENT BED PARO (ITXPARB=1) OR EQUIL TOX CON PART COEFF BETWEEN
        EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (liters/mg)
    CONPARB: EXPONENT IN TOXPAR=PARO*(CSED**CONPARB) IF ITXPARB=1
C   1   0.8770 -0.943   0.025
C45 NTOXN NSEDN ITXPARW TOXPARW CONPARW ITXPARB TOXPARB CONPARB COMMENTS

C45A TOXIC CONTAMINANT ORGANIC CARBON INTERACTION PARAMETERS
C
    ISTDOCW: 0 CONSTANT DOC IN WATER COLUMN OF STDOCWC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING DOC IN WATER COLUMN FROM docw.inp
    ISTPOCW: 0 CONSTANT POC IN WATER COLUMN OF STPOCWC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING POC IN WATER COLUMN FROM pocw.inp
            2 TIME CONSTANT, FPOC IN WATER COLUMN, SEE C45C
            3 TIME CONSTANT, SPATIALLY VARYING FPOC IN WATER COLUMN FORM fpocw.inp
            4 FUNTIONAL SPECIFICATION OF TIME AND SPATIALLY VARYING
                FPOC IN WATER COLUMN
    ISTDOCB: 0 CONSTANT DOC IN BED OF STDOCBC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING DOC IN BED FROM docb.inp
    ISTPOCB: 0 CONSTANT POC IN BED OF STPOCBC (DEFAULT=0.)
            1 TIME CONSTANT, SPATIALLY VARYING POC IN BED FROM pocb.inp
            2 TIME CONSTANT, FPOC IN BED, SEE C45D
            3 TIME CONSTANT, SPATIALLY VARYING FPOC IN BED FROM fpocb.inp
            4 FUNTIONAL SPECIFICATION OF TIME AND SPATIALLY VARYING
                FPOC IN BED
    STDOCWC: CONSTANT WATER COLUMN DOC (ISTDOCW=0)
    STPOCWC: CONSTANT WATER COLUMN POC (ISTPOCW=0)
    STDOCBC: CONSTANT BED DOC (ISTDOCB=0)

STPOCBC: CONSTANT BED POC (ISTPOCB=0)
C
C45A ISTDOCW ISTPOCW ISTDOCB ISTPOCB STDOCWC STPOCWC STDOCBC STPOCBC

C45B TOXIC CONTAMINANT ORGANIC CARBON INTERACTION PARAMETERS
C
C
    NTOXC: TOXIC CONTAMINANT NUMBER ID. NSEDC+NSEDN LINES OF DATA
        FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
    NOC : FIRST LINE FOR DISSOLVED ORGANIC CARBON, SECOND FOR PART OC
        REPEATED FOR EACH CONTAMINANT
    ITXPARW: -1 FOR NO ORGANIC CARBON, O FOR NORMAL PARTITION AND 1 FOR SOLIDS
        DEPENDENT TOXPAR=PARO*(CSED**CONPAR)
    TOXPARW: WATER COLUMN PARO (ITXPARW=1) OR EQUIL TOX CON PART COEFF BETWEEN
        EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (liters/mg)
    CONPARW: EXPONENT IN TOXPAR=PARO*(CSED**CONPARW) IF ITXPARW=1
    ITXPARB: CONVENTION FOLLOWS ITXPARW (BED)
    TOXPARB: SEDIMENT BED PARO (ITXPARB=1) OR EQUIL TOX CON PART COEFF BETWEEN
        EACH TOXIC IN WATER AND ASSOCIATED SEDIMENT PHASES (liters/mg)
    CONPARB: EXPONENT IN TOXPAR=PARO*(CSED**CONPARB) IF ITXPARB=1
C   1   0.8770 -0.943   0.025
C45B NTOXN NOC ITXPARW TOXPARW CONPARW ITXPARB TOXPARB CONPARB *CARBON*

C45C TOXIC CONTAMINANT POC FRACTIONAL DISTRIBUTIONS IN WATER COLUMN
C   1 LINE OF DATA REQUIRED EVEN IT ISTRAN(5) IS 0. DATA USED WHEN
C   ISTOC(NT)=1 OR 2

    NTOXN: TOXIC CONTAMINANT NUMBER ID. NSEDC+NSEDN 1 LINE OF DATA
        FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
  FPOCSED1-NSED: FRACTION OF OC ASSOCIATED WITH SED CLASSES 1,NSED
  FPOCSND1-NSND: FRACTION OF OC ASSOCIATED WITH SND CLASSES 1,NSND

C45C NTOXN FPOCSED1   FPOCSND1   FPOCSND2   FPOCSND3

C45D TOXIC CONTAMINANT POC FRACTIONAL DISTRIBUTIONS IN SEDIMENT BED
   1 LINE OF DATA REQUIRED EVEN IT ISTRAN(5) IS 0. DATA USED WHEN
   ISTOC(NT)=1 OR 2

    NTOXN: TOXIC CONTAMINANT NUMBER ID. NSEDC+NSEDN 1 LINE OF DATA
        FOR EACH TOXIC CONTAMINANT (DEFAULT = 2)
  FPOCSED1-NSED: FRACTION OF OC ASSOCIATED WITH SED CLASSES 1,NSED
  FPOCSND1-NSND: FRACTION OF OC ASSOCIATED WITH SND CLASSES 1,NSND

C45D NTOXN FPOCSED1   FPOCSND1   FPOCSND2   FPOCSND3

C46 BUOYANCY, TEMPERATURE, DYE DATA AND CONCENTRATION BC DATA
C
    BSC: BUOYANCY INFLUENCE COEFFICIENT 0 TO 1, BSC=1. FOR REAL PHYSICS
    TEMO: REFERENCE, INITIAL, EQUILIBRUM AND/OR ISOTHERMAL TEMP IN DEG C
    HEQT: EQUILIBRUM TEMPERTURE TRANSFER COEFFICIENT M/SEC
  ISBEDTEMI: 0 READ INTIAL BED TEMPERATURE FROM TEMPB.INP
        1 INITIALIZE AT START OF COLD RUN
    KBH: NUMBER OF BED THERMAL LAYERS
   RKDYE: FIRST ORDER DECAY RATE FOR DYE VARIABLE 1/SEC
    NCBS: NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON SOUTH OPEN
        BOUNDARIES
    NCBW: NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON WEST OPEN
        BOUNDARIES
    NCBE: NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON EAST OPEN
        BOUNDARIES
    NCBN: NUMBER OF CONCENTRATION BOUNDARY CONDITIONS ON NORTH OPEN
        BOUNDARIES
C
C46 BSC TEMO HEQT ISBEDTEMI,KBH RKDYE NCBS NCBW NCBE NCBN
   1.0 5.0 0.E-6 1   11 0.   0   0   0   0

C46A ICE EFFECTS
C

    ISICE: 1 FOR ICE EFFECTS ACTIVE
    ISICECOV: 0 USE START AND STOP JULIAN DAYS
                  1 READ ICE COVER FROM FILE ICECOVER.INP
                  2 SIMPLE CALCUATION USING AIR TEMPERATURE
                        3 COMPLEX CALCULATION (NOT ACTIVE)
    ISICETHK: 0 USE START AND STOP JULIAN DAYS AND MAX ICE THICKNESS
                  1 READ ICE THICKNESS FROM FILE ICECOVER.INP
                  2 SIMPLE CALCUATION USING AIR TEMPERATURE
                        3 COMPLEX CALCULATION (NOT ACTIVE)
    NISER: NUMBER OF ICE TIME SEREIS
    ICETHKFUN: 0 CONSTANT AT RICETHKMAX
                  1 LINEAR TO DYICEM1, LINEAR FROM DYICEM2
                        2 HALF COS WAVE TO TO DYICEM1, HALF COS FROM DYICEM2
    DYICEBEG: DAY ICE COVER BEGINS
         DYICEEND: DAY ICE COVER ENDS
         DYICEM1:   DAY MAXIMUM ICE COVER IS REACHED
         DYICEM2:   DAY MAXIMUM ICE THICKNESS STARTS TO DECAY
         RICETHKMAX: MAX ICE COVER THICKNESS, METERS
         TEMPICE: WATER TEMPERATURE AT WATER ICE INTERFACE FOR ISICECOV.LE.2
C
C46A ISICE ISICECOV ISICETHK NISER ICETHKFUN DYICEBEG DYICEEND DYICEM1 DYICEM2 RICETHKMAX
TEMPICE
    1 1   1   1   0   304   120   30   30   1.   0.1

C47 LOCATION OF CONC BC'S ON SOUTH BOUNDARIES
C

    ICBS: I CELL INDEX
    JCBS: J CELL INDEX
    NTSCRS: NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
        TO INFLOW FROM OUTFLOW
    NSSERS: SOUTH BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
    NTSERS: SOUTH BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
    NDSERS: SOUTH BOUNDARY CELL DYE CONC TIME SERIES ID NUMBER
    NSFSERS: SOUTH BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
    NTXSERS: SOUTH BOUNDARY CELL TOXIC CONTAMINANT CONC TIME SERIES ID NUM.
    NSDSERS: SOUTH BOUNDARY CELL COHESIVE SED CONC TIME SERIES ID NUMBER
    NSNSERS: SOUTH BOUNDARY CELL NONCOHESIVE SED CONC TIME SERIES ID NUMBER
C
C47 IBBS JBBS NTSCRS NSSERS NTSERS NDSERS NSFSERS NTXSERS NSDSERS NSNSERS

C48 TIME CONSTANT BOTTOM CONC ON SOUTH CONC BOUNDARIES
C

    SAL: ULTIMATE INFLOWING BOTTOM LAYER SALINITY
    TEM: ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
    DYE: ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
    SFL: ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRAION
    TOX: NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
        CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C48 SAL   TEM   DYE   SFL   TOX1

C49 TIME CONSTANT BOTTOM CONC ON SOUTH CONC BOUNDARIES
C

    SED: NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
        CONCENTRAIONS FIRST NSED VALUES SED(N), N=1,NSND
    SND: NSND ULTIMATE INFLOWING BOTTOM LAYER NONCOHESIVE SEDIMENT
        CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C49 SED1 SND1 SND2   SND3

C50 TIME CONSTANT SURFACE CONC ON SOUTH CONC BOUNDARIES
C

    SAL: ULTIMATE INFLOWING SURFAC LAYER SALINITY
    TEM: ULTIMATE INFLOWING SURFAC LAYER TEMPERATURE

```
        DYE:  ULTIMATE INFLOWING SURFAC LAYER DYE CONCENTRATION
        SFL:  ULTIMATE INFLOWING SURFAC LAYER SHELLFISH LARVAE CONCENTRAION
        TOX:  NTOX ULTIMATE INFLOWING SURFAC LAYER TOXIC CONTAMINANT
            CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C50 SAL   TEM   DYE   SFL   TOX1
------------------------------------------------------------------------
C51 TIME CONSTANT SURFACE CONC ON SOUTH CONC BOUNDARIES
C
        SED:  NSED ULTIMATE INFLOWING SURFAC LAYER COHESIVE SEDIMENT
            CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
        SND:  NSND ULTIMATE INFLOWING SURFAC LAYER NONCOHESIVE SEDIMENT
            CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C51 SED1  SND1  SND2   SND3
------------------------------------------------------------------------
C52 LOCATION OF CONC BC'S ON WEST BOUNDARIES AND SERIES IDENTIFIERS
C
        ICBW:   I CELL INDEX
        JCBW:   J CELL INDEX
        NTSCRW:  NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
            TO INFLOW FROM OUTFLOW
        NSSERW:  WEST BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
        NTSERW:  WEST BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
        NDSERW:  WEST BOUNDARY CELL DYE CONC TIME SERIES ID NUMBER
        NSFSERW: WEST BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
        NTXSERW: WEST BOUNDARY CELL TOXIC CONTAMINANT CONC TIME SERIES ID NUM.
        NSDSERW: WEST BOUNDARY CELL COHESIVE SED CONC TIME SERIES ID NUMBER
        NSNSERW: WEST BOUNDARY CELL NONCOHESIVE SED CONC TIME SERIES ID NUMBER
C
C52 IBBW  JBBW  NTSCRW NSSERW NTSERW NDSERW NSFSERW NTXSERW NSDSERW NSNSERW
------------------------------------------------------------------------
C53 TIME CONSTANT BOTTOM CONC ON WEST CONC BOUNDARIES
C
        SAL:  ULTIMATE INFLOWING BOTTOM LAYER SALINITY
        TEM:  ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
        DYE:  ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
        SFL:  ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRAION
        TOX:  NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
            CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C53 SAL   TEM   DYE   SFL   TOX1
------------------------------------------------------------------------
C54 TIME CONSTANT BOTTOM CONC ON WEST CONC BOUNDARIES
C
        SED:  NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
            CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
        SND:  NSND ULTIMATE INFLOWING BOTTOM LAYER NONCOHESIVE SEDIMENT
            CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C54  SED1  SND1
------------------------------------------------------------------------
C55 TIME CONSTANT SURFACE CONC ON WEST CONC BOUNDARIES
C
        SAL:  ULTIMATE INFLOWING SURFAC LAYER SALINITY
        TEM:  ULTIMATE INFLOWING SURFAC LAYER TEMPERATURE
        DYE:  ULTIMATE INFLOWING SURFAC LAYER DYE CONCENTRATION
        SFL:  ULTIMATE INFLOWING SURFAC LAYER SHELLFISH LARVAE CONCENTRAION
        TOX:  NTOX ULTIMATE INFLOWING SURFAC LAYER TOXIC CONTAMINANT
            CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C55 SAL   TEM   DYE   SFL   TOX1
------------------------------------------------------------------------
C56 TIME CONSTANT SURFACE CONC ON WEST CONC BOUNDARIES
C
        SED:  NSED ULTIMATE INFLOWING SURFAC LAYER COHESIVE SEDIMENT
```

```
             CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
        SND:  NSND ULTIMATE INFLOWING SURFAC LAYER NONCOHESIVE SEDIMENT
             CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C56  SED1  SND1
--------------------------------------------------------------------------------
C57 LOCATION OF CONC BC'S ON EAST BOUNDARIES AND SERIES IDENTIFIERS
C
     ICBE:   I CELL INDEX
     JCBE:   J CELL INDEX
     NTSCRE:  NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
          TO INFLOW FROM OUTFLOW
     NSSERE:  EAST BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
     NTSERE:  EAST BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
     NDSERE:  EAST BOUNDARY CELL DYE CONC TIME SERIES ID NUMBER
     NSFSERE: EAST BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
     NTXSERE: EAST BOUNDARY CELL TOXIC CONTAMINANT CONC TIME SERIES ID NUM.
     NSDSERE: EAST BOUNDARY CELL COHESIVE SED CONC TIME SERIES ID NUMBER
     NSNSERE: EAST BOUNDARY CELL NONCOHESIVE SED CONC TIME SERIES ID NUMBER
C
C57 IBBE  JBBE  NTSCRE NSSERE NTSERE NDSERE NSFSERE NTXSERE NSDSERE NSNSERE
--------------------------------------------------------------------------------
C58 TIME CONSTANT BOTTOM CONC ON EAST CONC BOUNDARIES
C
     SAL:  ULTIMATE INFLOWING BOTTOM LAYER SALINITY
     TEM:  ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
     DYE:  ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
     SFL:  ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRAION
     TOX:  NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
          CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C58 SAL   TEM   DYE   SFL   TOX1
--------------------------------------------------------------------------------
C59 TIME CONSTANT BOTTOM CONC ON EAST CONC BOUNDARIES
C
     SED:  NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
          CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
     SND:  NSND ULTIMATE INFLOWING BOTTOM LAYER NONCOHESIVE SEDIMENT
          CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C59  SED1  SND1
--------------------------------------------------------------------------------
C60 TIME CONSTANT SURFACE CONC ON EAST CONC BOUNDARIES
C
     SAL:  ULTIMATE INFLOWING SURFAC LAYER SALINITY
     TEM:  ULTIMATE INFLOWING SURFAC LAYER TEMPERATURE
     DYE:  ULTIMATE INFLOWING SURFAC LAYER DYE CONCENTRATION
     SFL:  ULTIMATE INFLOWING SURFAC LAYER SHELLFISH LARVAE CONCENTRAION
     TOX:  NTOX ULTIMATE INFLOWING SURFAC LAYER TOXIC CONTAMINANT
          CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C60 SAL   TEM   DYE   SFL   TOX1
--------------------------------------------------------------------------------
C61 TIME CONSTANT SURFACE CONC ON EAST CONC BOUNDARIES
C
     SED:  NSED ULTIMATE INFLOWING SURFAC LAYER COHESIVE SEDIMENT
          CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
     SND:  NSND ULTIMATE INFLOWING SURFAC LAYER NONCOHESIVE SEDIMENT
          CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C61  SED1  SND1
--------------------------------------------------------------------------------
C62 LOCATION OF CONC BC'S ON NORTH BOUNDARIES AND SERIES IDENTIFIERS
C
     ICBN:   I CELL INDEX
     JCBN:   J CELL INDEX
```

```
          NTSCRN: NUMBER OF TIME STEPS TO RECOVER SPECIFIED VALUES ON CHANGE
                TO INFLOW FROM OUTFLOW
          NSSERN: NORTH BOUNDARY CELL SALINITY TIME SERIES ID NUMBER
          NTSERN: NORTH BOUNDARY CELL TEMPERATURE TIME SERIES ID NUMBER
          NDSERN: NORTH BOUNDARY CELL DYE CONC TIME SERIES ID NUMBER
          NSFSERN: NORTH BOUNDARY CELL SHELLFISH LARVAE TIME SERIES ID NUMBER
          NTXSERN: NORTH BOUNDARY CELL TOXIC CONTAMINANT CONC TIME SERIES ID NUM.
          NSDSERN: NORTH BOUNDARY CELL COHESIVE SED CONC TIME SERIES ID NUMBER
          NSNSERN: NORTH BOUNDARY CELL NONCOHESIVE SED CONC TIME SERIES ID NUMBER
C
C62 IBBN  JBBN  NTSCRN NSSERN NTSERN NDSERN NSFSERN NTXSERN NSDSERN NSNSERN
--------------------------------------------------------------------------------
C63 TIME CONSTANT BOTTOM CONC ON NORTH CONC BOUNDARIES
C
          SAL:  ULTIMATE INFLOWING BOTTOM LAYER SALINITY
          TEM:  ULTIMATE INFLOWING BOTTOM LAYER TEMPERATURE
          DYE:  ULTIMATE INFLOWING BOTTOM LAYER DYE CONCENTRATION
          SFL:  ULTIMATE INFLOWING BOTTOM LAYER SHELLFISH LARVAE CONCENTRAION
          TOX:  NTOX ULTIMATE INFLOWING BOTTOM LAYER TOXIC CONTAMINANT
                CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C63 SAL  TEM  DYE SFL TOX1-20
--------------------------------------------------------------------------------
C64 TIME CONSTANT BOTTOM CONC ON NORTH CONC BOUNDARIES
C
          SED:  NSED ULTIMATE INFLOWING BOTTOM LAYER COHESIVE SEDIMENT
                CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
          SND:  NSND ULTIMATE INFLOWING BOTTOM LAYER NONCOHESIVE SEDIMENT
                CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C64  SED1  SED2  SND1  SND2  SND3
--------------------------------------------------------------------------------
C65 TIME CONSTANT SURFACE CONC ON NORTH CONC BOUNDARIES
C
          SAL:  ULTIMATE INFLOWING SURFAC LAYER SALINITY
          TEM:  ULTIMATE INFLOWING SURFAC LAYER TEMPERATURE
          DYE:  ULTIMATE INFLOWING SURFAC LAYER DYE CONCENTRATION
          SFL:  ULTIMATE INFLOWING SURFAC LAYER SHELLFISH LARVAE CONCENTRAION
          TOX:  NTOX ULTIMATE INFLOWING SURFAC LAYER TOXIC CONTAMINANT
                CONCENTRATIONS NTOX VALUES TOX(N), N=1,NTOX
C
C65 SAL  TEM  DYE SFL TOX1-20
--------------------------------------------------------------------------------
C66 TIME CONSTANT SURFACE CONC ON NORTH CONC BOUNDARIES
C
          SED:  NSED ULTIMATE INFLOWING SURFAC LAYER COHESIVE SEDIMENT
                CONCENTRAIONS  FIRST NSED VALUES SED(N), N=1,NSND
          SND:  NSND ULTIMATE INFLOWING SURFAC LAYER NONCOHESIVE SEDIMENT
                CONCENTRATIONS LAST NSND VALUES SND(N), N=1,NSND
C
C66  SED1  SED2  SND1  SND2  SND3
--------------------------------------------------------------------------------
C66a CONCENTRATION DATA ASSIMILATION
C
         NLCDA:  NUMBER OF HORIZONTAL LOCATIONS FOR DATA ASSIMILATION
         TSCDA:  WEIGHTING FACTOR, 0.-1., 1. = FULL ASSIMILATION
         ISCDA:  1 FOR CONCENTRATION DATA ASSIMILATION (NC=1.7 VALUES)
C
C66A NLCDA  TSCDA   ISCDA
     0    0.0    0 0 0 0 0   0  0
--------------------------------------------------------------------------------
C66B CONCENTRATION DATA ASSIMILATION
C
   ITPCDA: 0 ASSIMILATE DATA FROM TIME SERIES
           1 ASSIMIATED DATA FROM ANOTHER CELL IN GRID
    ICDA: I INDEX OF CELL ASSIMILATING DATA
```

```
        JCDA: J INDEX OF CELL ASSIMILATING DATA
       ICCDA: I INDEX OF CELL PROVIDING DATA, ITPCDA=1
       JCCDA: J INDEX OF CELL PROVIDING DATA, ITPCDA=1
      IDIRCDA: 0 NO DIRECTIONAL ASSIMILATION EFFECT
             1 POSITIVE EAST-WEST, 2 NEGATIVE EAST-WEST VELOCITY
                     3 POSITIVE NORTH-SOUTH, 4 NEGTIVE NORTH-SOUTH VELOCITY
     NCSERA:   ID OF TIME SERIES PROVIDING DATA
C    1   10 5  10    4 0 0  0  0 0 0 0 0 0
C66B ITPCDA  ICDA  JCDA ICCDA  JCCDA  IDIRCDA   NCSERA(NS=1,7)
-------------------------------------------------------------------------------
C67 DRIFTER DATA (FIRST 4 PARAMETER FOR SUB DRIFER, SECOND 6 FOR SUB LAGRES)
C
     ISPD:  1 TO ACTIVE SIMULTANEOUS RELEASE AND LAGRANGIAN TRANSPORT OF
             NEUTRALLY BUOYANT PARTICLE DRIFTERS AT LOCATIONS INPUT ON C44
     NPD:     NUMBER OF PARTICLE DIRIFERS
     NPDRT:   TIME STEP AT WHICH PARTICLES ARE RELEASED
     NWPD:    NUMBER OF TIME STEPS BETWEEN WRITING TO TRACKING FILE
          drifter.out
     ISLRPD: 1 TO ACTIVATE CALCULATION OF LAGRANGIAN MEAN VELOCITY OVER TIME
             INTERVAL TREF AND SPATIAL INTERVAL ILRPD1<I<ILRPD2,
             JLRPD1<J<JLRPD2, 1<K<KC, WITH MLRPDRT RELEASES.  ANY AVERGE
             OVER ALL RELEASE TIMES IS ALSO CALCULATED
            2 SAME BUT USES A HIGER ORDER TRAJECTORY INTEGRATION
     ILRPD1   WEST BOUNDARY OF REGION
     ILRPD2   EAST BOUNDARY OF REGION
     JLRPD1   NORTH BOUNDARY OF REGION
     JLRPD2   SOUTH BOUNDARY OF REGION
     MLRPDRT  NUMBER OF RELEASE TIMES
     IPLRPD   1,2,3 WRITE FILES TO PLOT ALL,EVEN,ODD HORIZ LAG VEL VECTORS
C
C67 ISPD NPD NPDRT NWPD ISLRPD ILRPD1 ILRPD2 JLRPD1  JLRPD2  MLRPDRT IPLRPD
   0   0  0  12   0    6    47   6     17    12   1
-------------------------------------------------------------------
C68 INITIAL DRIFTER POSITIONS (FOR USE WITH SUB DRIFTER)
C
     RI:  I CELL INDEX IN WHICH PARTICLE IS RELEASED IN
     RJ:  J CELL INDEX IN WHICH PARTICLE IS RELEASED IN
     RK:  K CELL INDEX IN WHICH PARTICLE IS RELEASED IN
C
C68  RI  RJ  RK
-------------------------------------------------------------------
C69 CONSTANTS FOR CARTESION GRID CELL CENTER LONGITUDE AND LATITUDE
C
     CDLON1:  6 CONSTANTS TO GIVE CELL CENTER LAT AND LON OR OTHER
     CDLON2:   COORDINATES FOR CARTESIAN GRIDS USING THE FORMULAS
     CDLON3:   DLON(L)=CDLON1+(CDLON2*FLOAT(I)+CDLON3)/60.
     CDLAT1:   DLAT(L)=CDLAT1+(CDLAT2*FLOAT(J)+CDLAT3)/60.
     CDLAT2:
     CDLAT3:
C
C69 CDLON1  CDLON2  CDLON3  CDLAT1  CDLAT2   CDLAT3
   0.0  0.0     0.0    0.0    0.0     0.0
-------------------------------------------------------------------
C70 CONTROLS FOR WRITING ASCII OR BINARY DUMP FILES
C
     ISDUMP: GREATER THAN 0 TO ACTIVATE
           1 SCALED ASCII INTERGER (0<VAL<65535)
           2 SCALED 16BIT BINARY INTEGER (0<VAL<65535) OR (-32768<VAL<32767)
           3 UNSCALED ASCII FLOATING POINT
           4 UNSCALED BINARY FLOATING POINT
     ISADMP: GREATER THAN 0 TO APPEND EXISTING DUMP FILES
     NSDUMP: NUMBER OF TIME STEPS BETWEEN DUMPS
     TSDUMP: STARTING TIME FOR DUMPS (NO DUMPS BEFORE THIS TIME)
     TEDUMP: ENDING TIME FOR DUMPS (NO DUMPS AFTER THIS TIME)
     ISDMPP: GREATER THAN 0 FOR WATER SURFACE ELEVATION DUMP
     ISDMPU: GREATER THAN 0 FOR HORIZONTAL VELOCITY DUMP
```

```
        ISDMPW: GREATER THAN 0 FOR VERTICAL VELOCITY DUMP
        ISDMPT: GREATER THAN 0 FOR TRANSPORTED VARIABLE DUMPS
       IADJDMP: 0 FOR SCALED BINARY INTEGERS (0<VAL<65535)
            -32768 FOR SCALED BINARY INTEGERS (-32768<VAL<32767)
 C
 C70 ISDUMP ISADMP NSDUMP TSDUMP TEDUMP ISDMPP ISDMPU ISDMPW ISDMPT IADJDMP
    0    0   10080  0.0   731.  0    0    0    1    -32768
 --------------------------------------------------------------------------
C71 CONTROLS FOR HORIZONTAL PLANE SCALAR FIELD CONTOURING
C
      ISSPH:  1 TO WRITE FILE FOR SCALAR FIELD CONTOURING IN HORIZONTAL PLANE
             2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      NPSPH:   NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISRSPH: 1 TO WRITE FILE FOR RESIDUAL SALINITY PLOTTING IN
             HORIZONTAL
      ISPHXY: 0 DOES NOT WRITE I,J,X,Y IN ***cnh.out and r***cnh.out FILES
             1 WRITES I,J ONLY IN ***cnh.out and r***cnh.out FILES
             2 WRITES I,J,X,Y  IN ***cnh.out and r***cnh.out FILES
             3 WRITES EFDC EXPLORER BINARY FORMAT FILES
      DATA LINE REPEATS 7 TIMES FOR SAL,TEM,DYE,SFL,TOX,SED,SND
C   1=HORIZONTAL TEMPERATURE ANIMATION
C71 ISSPH  NPSPH  ISRSPH  ISPHXY
    0    6    0    1    !SAL
    0    6    0    1    !TEM
    0    6    0    1    !DYE
    0    6    0    1    !SFL
    0    6    0    1    !TOX
    0    6    0    1    !SED
    0    6    0    1    !SND
 --------------------------------------------------------------------------
C71A CONTROLS FOR HORIZONTAL PLANE SEDIMENT BED PROPERTIES CONTOURING
C
      ISBPH:  1 TO WRITE FILES FOR SED BED PROPERTY CONTOURING IN HORIZONTAL
             2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
      ISBEXP: 0 ASCII FORMAT, 1 EXPLORER BINARY FORMAT
      NPBPH:   NUMBER OF WRITES PER REFERENCE TIME PERIOD
      ISRBPH: 1 TO WRITE FILES FOR RESIDUAL SED BED PROPERTY CONTOURING
      ISBBDN: 1 WRITE LAYER BULK DENSITY
      ISBLAY: 1 WRITE LAYER THICKNESSES
      ISBPOR: 1 WRITE LAYER POROSITY
      ISBSED: 1 WRITE COHESIVE SEDIMENT (MASS PER UNIT AREA)
             2 WRITE COHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT)
             3 WRITE COHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT+WATER)
      ISBSED: 1 WRITE NONCOHESIVE SEDIMENT (MASS PER UNIT AREA)
             2 WRITE NONOOHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT)
             3 WRITE NONCOHESIVE SEDIMENT (FRACTION OF TOTAL SEDIMENT+WATER)
      ISBVDR: 1 WRITE LAYER VOID RATIOS
      ISBARD: 1 WRITES ACCUMMULATED MASS/AREA RESUSPENSION AND DEPOSITION FOR
             EACH SEDIMENT CLASS TO ASCII FILE BEDARD.OUT FOR ISBEXP=0 OR 1
C
C71A ISBPH ISBEXP NPBPH ISRBPH ISBBDN ISBLAY ISBPOR ISBSED ISBSND ISBVDR ISBARD
     0    0    1    0    0    1    0    1    1    1    0
 --------------------------------------------------------------------------
C71B FOOD CHAIN MODEL OUTPUT CONTROL
C
      ISFDCH: 1 TO WRITE OUTPUT FOR HOUSATONIC RIVER FOOD CHAIN MODEL
      NFDCHZ: NUMBER OF SPATIAL ZONES
      HBFDCH: AVERAGING DEPTH FOR TOP PORTION OF BED (METERS)
      TFCAVG: TIME AVERAGING INTERVAL FOR FOOD CHAIN OUTPUT (SECONDS)
C
C71B ISFDCH  NFDCHZ  HBFDCH   TFCAVG
    0    5   0.1524  86400.
 --------------------------------------------------------------------------
C72 CONTROLS FOR HORIZONTAL SURFACE ELEVATION OR PRESSURE CONTOURING
C
      ISPPH:  1 TO WRITE FILE FOR SURF ELEVATION CONTOURING
```

```
            2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
        NPPPH:   NUMBER OF WRITES PER REFERENCE TIME PERIOD
        ISRPPH: 1 TO WRITE FILE FOR RESIDUAL SURFACE ELEVATION  CONTOURNG IN
            HORIZONTAL PLANE
        IPPHXY: 0 DOES NOT WRITE I,J,X,Y IN surfplt.out and rsurfplt.out FILES
            1 WRITES I,J ONLY IN surfplt.out and rsurfplt.out FILES
            2 WRITES I,J,X,Y  IN surfplt.out and rsurfplt.out FILES
            3 WRITES EFDC EXPLORER BINARY FORMAT FILES
C
C72 ISPPH   NPPPH   ISRPPH  IPPHXY
    0     1     0      2
-------------------------------------------------------------------------------
C73 CONTROLS FOR HORIZONTAL PLANE VELOCITY VECTOR PLOTTING
C
        ISVPH:  1 TO WRITE FILE FOR VELOCITY PLOTTING IN HORIZONTAL PLANE
            2 WRITE ONLY DURING LAST REFERENCE TIME PERIOD
        NPVPH:   NUMBER OF WRITES PER REFERENCE TIME PERIOD
        ISRVPH: 1 TO WRITE FILE FOR RESIDUAL VELOCITY PLOTTIN IN
            HORIZONTAL PLANE
        IVPHXY: 0 DOES NOT WRITE I,J,X,Y IN velplth.out and rvelplth.out FILES
            1 WRITES I,J ONLY IN velplth.out and rvelplth.out FILES
            2 WRITES I,J,X,Y  IN velplth.out and rvelplth.out FILES
            3 WRITES EFDC EXPLORER BINARY FORMAT FILES
C
C73 ISVPH   NPVPH   ISRVPH  IVPHXY
    0     1     0      2
-------------------------------------------------------------------------------
C74 CONTROLS FOR VERTICAL PLANE SCALAR FIELD CONTOURING
C
        ISECSPV:  N AN INTEGER NUMBER OF VERTICAL SECTIONS (N.LE.9) TO WRITE
            N FILES FOR SCALAR  FIELD CONTOURING
        NPSPV:     NUMBER OF WRITES PER REFERENCE TIME PERIOD
        ISSPV:    1 TO ACTIVATE INSTANTANEOUS SCALAR FIELDS
            2 TO WRITE ONLY DURING LAST REFERENCE TIME PERIOD
        ISRSPV:   1 TO ACTIVATE FOR RESIDUAL SCALAR FIELDS
        ISHPLTV: 1 FOR VERTICAL PLANE PLOTTING FOR MSL DATUMS, ZERO OTHERWISE
        DATA LINE REPEATS 7 TIMES FOR SAL,TEM,DYE,SFL,TOX,SED,SND
        ISECSPV IS DETERMINED FOR ALL 7 VARIABLES BY VALUE ON FIRST DATA LINE
C
C74 ISECSPV   NPSPV  ISSPV  ISRSPV  ISHPLTV
    0     24    0    0     1      !SAL
    0     6    0    0     1      !TEM
    0     6    0    0     1      !DYE
    0     6    0    0     1      !SFL
    0     6    0    0     1      !TOX
    0     6    0    0     1      !SED
    0     6    0    0     1      !SND
-------------------------------------------------------------------------------
C75 MORE CONTROLS FOR VERTICAL PLANE SCALAR FIELD CONTOURING
C
        ISECSPV:  SECTION NUMBER
        NIJSPV:   NUMBER OF CELLS OR I,J PAIRS IN SECTION
        SEC ID:   CHARACTER FORMAT SECTION TITLE
C
C75 ISECSPV NIJSPV  SEC ID
-------------------------------------------------------------------------------
C76 I,J LOCATIONS FOR VERTICAL PLANE SCALAR FIELD CONTOURING
C
        ISECSPV: SECTION NUMBER
        ISPV:   I CELL
        JSPV:   J CELL
C
C76 ISECSPV ISPV   JSPV
-------------------------------------------------------------------------------
C77 CONTROLS FOR VERTICAL PLANE VELOCITY VECTOR PLOTTING
C
```

```
        ISECVPV: N AN INTEGER NUMBER (N.LE.9) OF VERTICAL SECTIONS
                TO WRITE N FILES FOR VELOCITY PLOTTING
        NPVPV:    NUMBER OF WRITES PER REFERENCE TIME PERIOD
        ISVPV:   1 TO ACTIVATE INSTANTANEOUS VELOCITY
                2 TO WRITE ONLY DURING LAST REFERENCE TIME PERIOD
        ISRSPV:  1 TO ACTIVATE FOR RESIDUAL VELOCITY
C
C77 ISECVPV  NPVPV  ISVPV  ISRSPV
     0     6    0    0
--------------------------------------------------------------------------------
C78 MORE CONTROLS FOR VERTICAL PLANE VELOCITY VECTOR PLOTTING
C
        ISCEVPV:  SECTION NUMBER
        NIJVPV:   NUMBER IS CELLS OR I,J PAIRS IN SECTION
        ANGVPV:   CCW POSITIVE ANGLE FROM EAST TO SECTION NORMAL
        SEC ID:   CHARACTER FORMAT SECTION TITLE
C
C78 ISECVPV   NIJVPV   ANGVPV  SEC ID
--------------------------------------------------------------------------------
C79 CONTROLS FOR VERTICAL PLANE VELOCITY PLOTTING
C
        ISECVPV:  SECTION NUMBER (REFERENCE USE HERE)
        IVPV:    I CELL INDEX
        JVPV:    J CELL INDEX
C
C79 ISECVPV IVPV    JVPV
--------------------------------------------------------------------------------
C80 CONTROLS FOR 3D FIELD OUTPUT
C
        IS3DO: 1 TO WRITE TO 3D ASCI INTEGER FORMAT FILES, JS3Dvar.LE.2    SEE
               1 TO WRITE TO 3D ASCI FLOAT POINT FORMAT FILES, JS3Dvar.EQ.3 C57
               2 TO WRITE TO 3D CHARACTER ARRAY FORMAT FILES (NOT ACTIVE)
               3 TO WRITE TO 3D HDF IMAGE FORMAT FILES (NOT ACTIVE)
               4 TO WRITE TO 3D HDF FLOATING POINT FORMAT FILES (NOT ACTIVE)
        ISR3DO:  SAME AS IS3DO EXCEPT FOR RESIDUAL VARIABLES
        NP3DO:   NUMBER OF WRITES PER LAST REF TIME PERIOD FOR INST VARIABLES
        KPC:     NUMBER OF UNSTRETCHED PHYSICAL VERTICAL LAYERS
        NWGG:    IF NWGG IS GREATER THAN ZERO, NWGG DEFINES THE NUMBER OF !2877
                WATER CELLS IN CARTESIAN 3D GRAPHICS GRID OVERLAY OF THE
                CURVILINEAR GRID. FOR NWGG>0 AND EFDC RUNS ON A CURVILINEAR
                GRID, I3DMI,I3DMA,J3DMI,J3DMA REFER TO CELL INDICES ON THE
                ON THE CARTESIAN GRAPHICS GRID OVERLAY DEFINED BY FILE
                gcell.inp.  THE FILE gcell.inp IS NOT USED BY EFDC, BUT BY
                THE COMPANION GRID GENERATION CODE GEFDC.F.  INFORMATION
                DEFINING THE OVERLAY IS READ BY EFDC.F FROM THE FILE
                gcellmp.inp. IF NWGG EQUALS 0, I3DMI,I3DMA,J3DMI,J3DMA REFER
                TO INDICES ON THE EFDC GRID DEFINED BY cell.inp.
                ACTIVATION OF THE REWRITE OPTION I3DRW=1 WRITES TO THE FULL
                GRID DEFINED BY cell.inp AS IF cell.inp DEFINES A CARTESIAN
                GRID.  IF NWGG EQ 0 AND THE EFDC COMP GRID IS CO, THE REWRITE
                OPTION IS NOT RECOMMENDED AND A POST PROCESSOR SHOULD BE USED
                TO TRANSFER THE SHORT FORM, I3DRW=0, OUTPUT TO AN APPROPRIATE
                FORMAT FOR VISUALIZATION. CONTACT DEVELOPER FOR MORE DETAILS
        I3DMI:   MINIMUM OR BEGINNING I INDEX FOR 3D ARRAY OUTPUT
        I3DMA:   MAXIMUM OR ENDING I INDEX FOR 3D ARRAY OUTPUT
        J3DMI:   MINIMUM OR BEGINNING J INDEX FOR 3D ARRAY OUTPUT
        J3DMA:   MAXIMUM OR ENDING J INDEX FOR 3D ARRAY OUTPUT
        I3DRW:  0 FILES WRITTEN FOR ACTIVE CO WATER CELLS ONLY
                1 REWRITE FILES TO CORRECT ORIENTATION DEFINED BY gcell.inp
                 AND gcellmp.inp FOR CO WITH NWGG.GT.O OR BY cell.inp IF THE
                 COMPUTATIONAL GRID IS CARTESIAN AND NWGG.EQ.0
        SELVMAX: MAXIMUM SURFACE ELEVATION FOR UNSTRETCHING (ABOVE MAX SELV )
        BELVMIN: MINIMUM BOTTOM ELEVATION FOR UNSTRETCHING (BELOW MIN BELV)
C
C80 IS3DO ISR3DO NP3DO KPC NWGG I3DMI I3DMA J3DMI J3DMA I3DRW SELVMAX BELVMIN
     0    0     0    1   0    1    62    1   118   0    15.0   -315.
```

```
--------------------------------------------------------------------------
C81 OUTPUT ACTIVATION AND SCALES FOR 3D FIELD OUTPUT
C
    VARIABLE:    DUMMY VARIBLE ID (DO NOT CHANGE ORDER)
    IS3(VARID): 1 TO ACTIVATE THIS VARIBLES
    JS3(VARID): 0 FOR NO SCALING OF THIS VARIABLE
            1 FOR AUTO SCALING OF THIS VARIABLE OVER RANGE 0<VAL<255
            AUTO SCALES FOR EACH FRAME OUTPUT IN FILES out3d.dia AND
            rout3d.dia  OUTPUT IN I4 FORMAT
            2 FOR SCALING SPECIFIED IN NEXT TWO COLUMNS WITH OUTPUT
            DEFINED OVER RANGE  0<VAL<255 AND WRITTEN IN I4 FORMAT
            3 FOR MULTIPLIER SCALING BY MAX SCALE VALUE WITH OUTPUT
            WRITTEN IN F7.1 FORMAT (IS3DO AND ISR3DO MUST BE 1)
C
C81 VARIABLE    IS3D(VARID) JS3D(VARID)  MAX SCALE VALUE  MIN SCALE VALUE
    'U VEL'   1         3         100.0          -1.0
    'V VEL'   1         3         100.0          -1.0
    'W VEL'   0         0         1000.0         -1.0E-3
    'SALINITY' 1        3          1.0            0.0
    'TEMP'    1         3          1.0           10.0
    'DYE'     0         0         1000.0          0.0
    'COH SED'  1        3         1000.0          0.0
    'NCH SED'  1        3         1000.0          0.0
    'TOX CON'  1        3         1000.0          0.0
--------------------------------------------------------------------------
C82 INPLACE HARMONIC ANALYSIS PARAMETERS
C
    ISLSHA: 1 FOR IN PLACE LEAST SQUARES HARMONIC ANALYSIS
    MLLSHA: NUMBER OF LOCATIONS FOR LSHA
    NTCLSHA: LENGTH OF LSHA IN INTEGER NUMBER OF REFERENCE TIME PERIODS
    ISLSTR: 1 FOR TREND REMOVAL
    ISHTA : 1 FOR SINGLE TREF PERIOD SURFACE ELEV ANALYSIS
C           90
C82 ISLSHA MLLSHA  NTCLSHA ISLSTR ISHTA
    0    0    32    0    0
--------------------------------------------------------------------------
C83 HARMONIC ANALYSIS LOCATIONS AND SWITCHES
C
    ILLSHA:  I CELL INDEX
    JLLSHA:  J CELL INDEX
    LSHAP: 1 FOR ANALYSIS OF SURFACE ELEVATION
    LSHAB: 1 FOR ANALYSIS OF SALINITY
    LSHAUE: 1 FOR ANALYSIS OF EXTERNAL MODE HORIZONTAL VELOCITY
    LSHAU: 1 FOR ANALYSIS OF HORIZONTAL VELOCITY IN EVERY LAYER
    CLSL:    LOCATION AS A CHARACTER VARIALBLE
C
C83 ILLSHA  JLLSHA  LSHAP  LSHAB  LSHAUE LSHAU  CLSL
--------------------------------------------------------------------------
C84 CONTROLS FOR WRITING TO TIME SERIES FILES
C
    ISTMSR: 1 OR 2 TO WRITE TIME SERIES OF SURF ELEV, VELOCITY, NET
            INTERNAL AND EXTERNAL MODE VOLUME SOURCE-SINKS, AND
            CONCENTRATION VARIABLES, 2 APPENDS EXISTING TIME SERIES FILES
    MLTMSR: NUMBER HORIZONTAL LOCATIONS TO WRITE TIME SERIES OF SURF ELEV,
            VELOCITY, AND CONCENTRATION VARIABLES, MAXIMUM LOCATIONS = 9
    NBTMSR: TIME STEP TO BEGIN WRITING TO TIME SERIES FILES
    NSTMSR: TIME STEP TO STOP WRITING TO TIME SERIES FILES
    NWTSER: WRITE INTERVAL FOR WRITING TO TIME SERIES FILES
    NTSSTSP: NUMBER OF TIME SERIES START-STOP SCENARIOS, 1 OR GREATER
    TCTMSR: UNIT CONVERSION FOR TIME SERIES TIME. FOR SECONDS, MINUTES,
            HOURS,DAYS USE 1.0, 60.0, 3600.0, 86400.0 RESPECTIVELY
     IDUM: 2 DUMMY INTEGER VARIABLES REQUIRED, BOTH = 0
C               7200
C84 ISTMSR  MLTMSR  NBTMSR  NSTMSR  NWTMSR  NTSSTSP  TCTMSR   IDUM  IDUM
    1      12    0 20000000 600    1      86400.  0    0
--------------------------------------------------------------------------
```

C85 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ITSSS: START-STOP SCENARIO NUMBER 1.GE.ISSS.LE.NTSSTSP
  MTSSTSP: NUMBER OF STOP-START PAIRS FOR SCENARIO ISSS
C
C85 ITSSS MTSSTSP
   1   1   !FULL SAVE

C86 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ITSSS: START-STOP SCENARIO NUMBER 1.GE.ISSS.LE.NTSSTSP
   MTSSS: NUMBER OF STOP-START PAIRS FOR SCENARIO ISSS
   TSSTRT: STARTING TIME FOR SCENARIO ITSSS, SAVE INTERVAL MTSSS
   TSSTOP: STOPING TIME FOR SCENARIO ITSSS, SAVE INTERVAL MTSSS
C   212.
C86 ISSS MTSSS   TSSTRT   TSSTOP   USER COMMENT
   1   1   -1000.   20000.   ! FULL SAVE

C87 CONTROLS FOR WRITING TO TIME SERIES FILES
C
   ILTS: I CELL INDEX
   JLTS: J CELL INDEX
  NTSSSS: WRITE SCENARIO FOR THIS LOCATION
   MTSP: 1 FOR TIME SERIES OF SURFACE ELEVATION
   MTSC: 1 FOR TIME SERIES OF TRANSPORTED CONCENTRATION VARIABLES
   MTSA: 1 FOR TIME SERIES OF EDDY VISCOSITY AND DIFFUSIVITY
   MTSUE: 1 FOR TIME SERIES OF EXTERNAL MODE HORIZONTAL VELOCITY
   MTSUT: 1 FOR TIME SERIES OF EXTERNAL MODE HORIZONTAL TRANSPORT
   MTSU: 1 FOR TIME SERIES OF HORIZONTAL VELOCITY IN EVERY LAYER
   MTSQE: 1 FOR TIME SERIES OF NET EXTERNAL MODE VOLUME SOURCE/SINK
   MTSQ: 1 FOR TIME SERIES OF NET EXTERNAL MODE VOLUME SOURCE/SINK
   CLTS: LOCATION AS A CHARACTER VARIALBLE
C
C87 ILTS JLTS NTSSSS MTSP MTSC MTSA MTSUE MTSUT MTSU MTSQE MTSQ CLTS
  6 103 1   1   1   0   0   0   0   0   0 'NS=1 NSR at Edmonton flow station'
  6 565 1   1   1   0   0   0   0   0   0 'NS=2 NSR at Deer crk flow station'
  6 153 1   1   1   0   0   0. 0   0   0 'NS=3 U/S OF CAPITAL REGION WWTP DISCHARGE AT RIGHT
BANK'
  6 175 1   1   1   0   0   0   0   0   0 'NS=4 FORT SASKATCHEWAN BOAT LAUNCH - TRANSECT'
  6 178 1   1   1   0   0   0   0   0   0 'NS=5 HWY 15 BRIDGE - TRANSECT'
  6 187 1   1   1   0   0   0   0   0   0 'NS=6 US of RR Trestle'
  6 188 1   1   1   0   0   0   0   0   0 'NS=7 DS of RR Trestle'
  6 220 1   1   1   0   0   0   0   0   0 'NS=8 VINCA BRIDGE - TRANSECT'
  6 265 1   1   1   0   0   0   0   0   0 'NS=9 WASKATENAU BRIDGE - TRANSECT'
  6 304 1   1   1   0   0   0   0   0   0 'NS=10 PAKAN BRIDGE'
  6 499 1   1   1   0   0   0   0   0   0 'NS=11 LEA PARK BRIDGE - TRANSECT'
  6 12 1   1   1   0   0   0   0   0   0 'NS=12 Devon '

C88 CONTROLS FOR EXTRACTING INSTANTANEOUS VERTICAL SCALAR FIELD PROFILES
C
   ISVSFP: 1 FOR EXTRACTING INSTANTANEOUS VERTICAL FIELD PROFILES
   MDVSFP: MAXIMUM NUMBER OF DEPTHS FOR SAMPLING VALUES
   MLVSFP: NUMBER OF HORIZONTAL SPACE-TIME LOCATION PAIRS TO BE SAMPLED
   TMVSFP: MULTIPLIER TO CONVERT SAMPLING TIMES TO SECONDS
   TAVSFP: ADDITIVE ADJUSTMENT TO SAMPLING TIME BEFORE CONVERSION TO SEC
C   200max 1600max
C88 ISVSFP MDVSFP MLVSFP TMVSFP TAVSFP
  0   0   0   86400. 0.0

C89 SAMPLING DEPTHS FOR EXTRACTING INST VERTICAL SCALAR FIELD PROFILES
C
   MMDVSFP: Mth SAMPLING DEPTH
   DMSFP: SAMPLING DEPTH BELOW SURFACE, IN METERS
C
C89 MMDVSFP DMVSFP

```
C90 HORIZONTAL SPACE-TIME LOCATIONS FOR SAMPLING
C
     MMLVSFP:  Mth SPACE TIME SAMPLING LOCATION                    I
     TIMVSFP:  SAMPLING TIME
     IVSFP:    I HORIZONTAL LOCATON INDEX
     JVSFP:    J HORIZONTAL LOCATON INDEX
C
C90 MMLVSFP  TIMVSFP  IVSFP  JVSFP
*********************************************************************************
*********************************************************************************
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```